The AMSAT Journal

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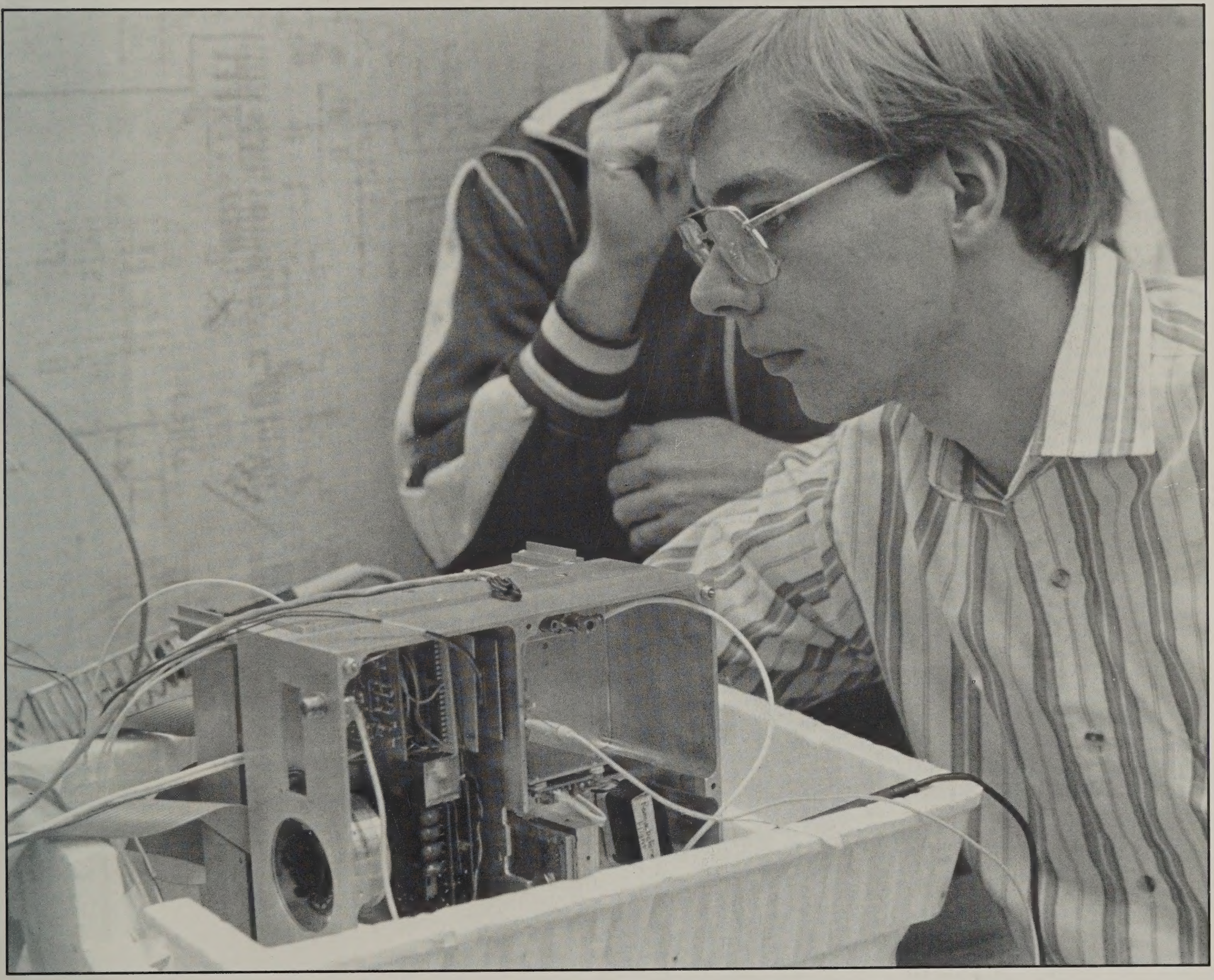

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Our cover: Greg Allen, a student in Electronics Engineering Technology, is shown here performing thermal testing of a flash digitizer at Weber State College, Ogden, Utah. For more on Weber State College, see pages 11 and 35.

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Off the Pad

An Editorial

By Joe Kasser, W3/G3ZCZ

This issue of the *Journal* is somewhat special. Each year AMSAT holds a Space Symposium at the same time as the Annual Meeting. At this symposium papers are presented that cover the advances in technology made that year and plans and ideas for the future. Copies of the papers are printed and bound into a proceedings for distribution both at the symposium and to those unable to attend.

(Continued on page 38)

President's Forward to the 1989 Proceedings

In the past several years AMSAT has published a comprehensive proceedings of our Space Symposium activity. This practice was begun by Al Brinkerhoff, WB5PMR, and the capable volunteers who helped him put together the 1986 Annual Meeting in Dallas. This practice has been followed by the hosts of every AMSAT Space Symposium since the Dallas meeting and has proven to be popular with

(Continued on page 39)

WEATHER SATELLITE IMAGERY
High Resolution Picture Transmission: The Next Challenge

By
Jeff Wallach, N5ITU
Chairman, Dallas Remote Imaging Group

Over the past several years, Amateur reception of polar orbiting weather satellite imagery has become increasingly sophisticated and accessible to Amateur Radio operators. There is now a large population of hams and non-hams alike that receive weather satellite pictures from American and Soviet polar orbiters on a daily basis. These high resolution images can be captured with simple receivers in the vhf range and displayed on various types of personal computers. Commercial paint programs for the PC and other digital image enhancement routines commonly available to the public allow for sophisticated post-processing of these pictures for temperature analyses, colorization of land and sea features, three dimensional perspectives, etc.

The National Oceanic and Atmospheric Administration (NOAA) operates two polar orbiting weather satellites. These birds circle the earth in a north-south orbit (inclination of 98 degrees) passing over both the North and South polar regions. One satellite crosses the equator in the morning and the other in the afternoon. These polar orbiters circle in a "sun-synchronous" orbit of approximately 850 km and each observes the entire Earth twice a day. Typical orbit periods are 102 minutes. Since these satellites are sun synchronous, they orbit the Earth so that they cross the equator at the same time daily. The morning satellite (NOAA 10) crosses southward over the equator at 7:30 AM local time and the afternoon bird (NOAA 11) crosses northward about 2:30 PM local time. Operating together as a pair, these satellites assure that measurements for any region of the Earth are no more than six hours old.

These polar orbiters provide visible and infrared radiometer data that are used for imaging purposes, radiation measurements, and vertical temperature profiles, and can help calculate water vapor content at several atmospheric levels. The primary sensor for these measurements is called the Advanced Very High Resolution Radiometer (AVHRR), which is just one of several sensors on the satellite bus. This is a radiation-detection instrument used to remotely determine cloud cover and surface temperature. This scanning radiometer uses five detectors that collect different bands of radiation wavelengths. Measuring the same view, this array of diverse wavelengths, after processing, will permit multispectral analysis for analyzing oceanographic, meteorological, and hydrological parameters. One channel of the sensor will measure energy in the visible band and another in the near infrared portion of the electromagnetic spectrum to observe clouds, snow, ice, shorelines, vegetation, etc. Comparison of data from these two channels can indicate the onset of ice and snow melting. Depending on which instrument is used, the other two or three channels operate entirely within the infrared band to detect the heat radiation from the clouds, land, water, and sea surface. Figure 1 diagrammatically displays the AVHRR radiometer on the Advanced TIROS satellite bus.

The AVHRR instrument provides several "products" for the direct readout community. One of these products is known as Automatic Picture Transmission (APT). APT is one operational mode for data transmitted from the AVHRR instrument on the NOAA polar satellites. This data is constantly transmitted to ground stations with a resolution of 4 kilometers. The following chart describes the APT transmission characteristics:

APT Parameters

Type of signal	VHF, AM/PM
System Output	137.5 MHz RHC, 137.62 MHz RHC
Power	5.0 Watts
Subcarrier Frequency	2400 Hz
Carrier deviation	35 kHz
Line rate	120 lpm
Data resolution	4 km uniform
Synchronization	7 pulses at 1040 pps (visible Channel 1) 7 pulses at 832 pps (IR Channel 2)

The APT product is the one that the majority of the Amateur community has been capturing with personal computers and digital framestore units. With a transmit frequency in the 137 MHz range, both the vhf receiver and turnstile or beam antenna offer a fairly simple rf subsystem to design and construct for APT imagery reception. A simple AM demodulator can detect the 2400 Hz AM subcarrier impressed on the FM signal, fed into a analog to digital converter chip, and then into the printer port on the personal computer. Figure 2 is a typical APT imagery shot taken in Dallas from NOAA 8. Notice the detail even at a resolution of 4 km. There have been hundreds of Amateurs that have copied the downlink imagery on a daily basis. With the advent of the higher resolution PC display boards (Super VGA) that can display up to 8 bits of data (256 shades of grey), outstanding imagery is now commonplace.

However..... in the spirit of the Amateur community we are always striving to that next step, that higher resolution which challenges our ingenuity and abilities... that next step is now High Resolution Picture Transmission (HRPT) products.

HRPT

HRPT is another product from the AVHRR radiometer onboard the satellite

Advanced TIROS — N (ATN)

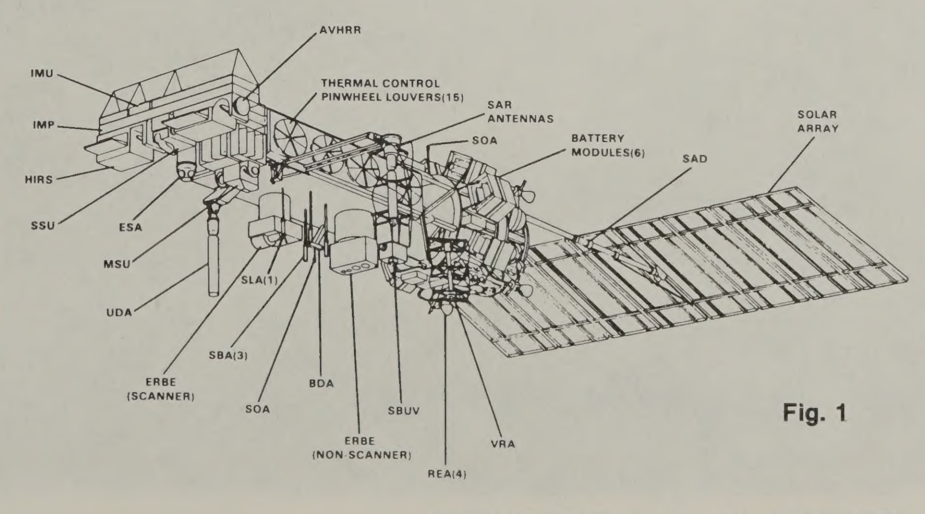


Fig. 1

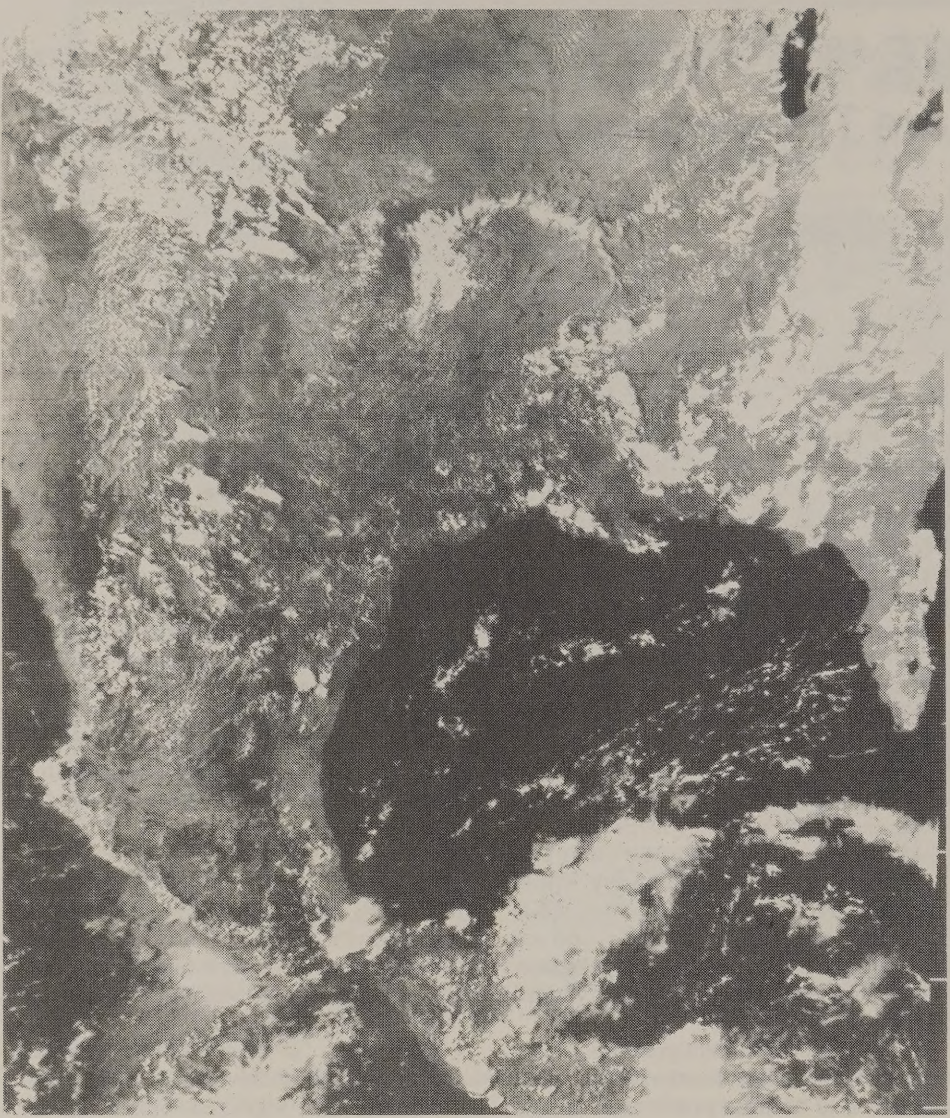
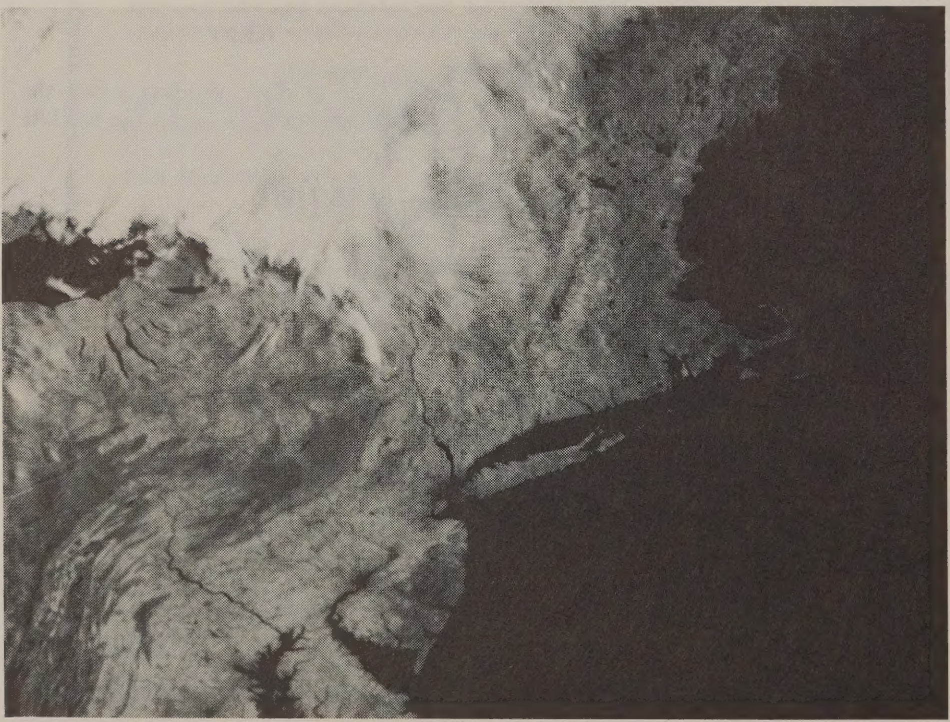


Fig. 2

Fig. 3



bus. HRPT is the operational mode for data broadcast from the AVHRR instrument that has a much higher resolution compared to APT. This data product is continually transmitted to all ground stations at a resolution of 1.1 km. It is downlinked in all five spectral channels, two visible, three infrared. The HRPT data format provides a time multiplexed output of five channels from the AVHRR and additional low bit rate from other instrument data. The data are digital, transmitted in the S Band frequencies. All information necessary to calibrate the instrument output is included in the data stream. The next chart outlines the characteristics ot the HRPT data:

HRPT Parameters

Transmitted signal	S band phase modulated Split phase 665.4 kbps.
Frequency	1698 MHz RHC, 1707 MHz RHC
Power	5.25 Watts
Line rate	360 lines per minute (lpm)
Data channels	5
Data resolution	1.1 km
Carrier Modulation	Digital, split phase phase modulator

The major efforts to develop Amateur HRPT groundstations have been spearheaded by John DuBois, WIHDX, and Ed Murashie. The first major Amateur HRPT station was completed on April 4, 1988 by John DuBois. John's station consists of a four-foot parabolic dish reflector fed by a typical WEFAX type circular horn fitted with two pickup probes combined in phase quadrature to archive circular polarization. The LNA specifications are 1 dB noise figure, 35 dB gain figure, and it is attached to the rear of the feed horn. The antenna is mounted on a Yaesu 5400A el/az rotator system. The beamwidth of the four-foot dish is sufficiently broad, about 17 degrees, that manual tracking of the satellite is practical.

The down converter is a standard Microwave Modules converter with the crystals changed for 1698 and 1707 MHz and 70 MHz IF output. The IF is amplified 30 dB, fed through a second converter to 10.7 MHz and amplified to about -30 dbm. A two pole synchronously tuned filter with 1.7 MHz bandwidth is used at this point to approximate a matched filter. An LC phase locked loop at 10.7 MHz serves as a phase detector and the data output is sent through a low pass filter to 1.7 MHz. The bit synchronizer to separate clock and data uses an edge detector and phase locked loop, followed by an integrate and dump circuit to decode the split-phase (Manchester) data modulation. The frame synchronizer is relatively simple to con-

struct. The start of line synchronization word is detected by a TRW 1023 correlator chip and simple counters locate the 10 bit word boundaries for each of the five spectral channels. Data words from a selected single channel are fed to an IBM PC/XT (faster processors are NOT necessary!) over a parallel interface and displayed on an AT&T Targa 512 x 512 frame buffer.

One line of image, from a single channel, consists of 2048 ten bit words. The entire line takes 166.67 milliseconds and individual words are spaced at 75.14 microseconds with some unused time before and after the image data. As APT users are aware, the extreme edges of the imagery are foreshortened and since the display will not handle 2048 pixels across the line, the middle 512 pixels are selected, and the rest of the line is discarded. There is sufficient time at the end of a line to save these 512 bytes direct to hard disk. A 10 to 15 minute pass results in about 2.5 MBytes of data stored which can later be edited for desirable images.

The resulting images have similar ground resolution at nadir compared to GOES VAS (1 km) but because of the more favorable viewpoint for many regions, pictures are frequently spectacular. The HRPT system described herein is much simpler than GOES VAS systems previously developed by John DuBois — the downconverter, antenna and display system are almost identical to a WEFAX station, and John and Ed Murashie are well underway with printed circuit boards for the IBM PC bus system. The following imagery was captured from NOAA 10 and NOAA 11 using the HRPT transmissions. Compare the excellent detail of the HRPT imagery to that of the APT imagery previously shown. The first image (Figure 3) is that of the Northeast U.S. taken from NOAA 10 in visible mode. The next two images (Figures 4 and 5) were taken by NOAA 11 on 4/17/89 in visible mode and give detailed images of the Salton Sea in California and Lake Powell and the Grand Canyon. The sixth image (Figure 6) was captured by NOAA 9 in January 1988, and is a visible image from the AVHRR instrument of the B-9 iceberg which broke off the Ross Ice Shell in Antarctica late in 1987, and was first spotted by a NOAA polar orbiting weather satellite. This iceberg is estimated to be twice the size of Rhode Island and to contain enough water to supply the city of Los Angeles for several hundred years! This particular photo was image enhanced by the Navy-NOAA Joint Ice Center, Suitland, Maryland.

The author may be contacted at the following address: Jeff Wallach, Phd. N5ITU, Chairman, Dallas Remote Imaging Group, PO Box 118053, Carrollton, Texas 75011-8058. 214-394-7325 (voice) 214-394-7488 (DRIG BBS system)

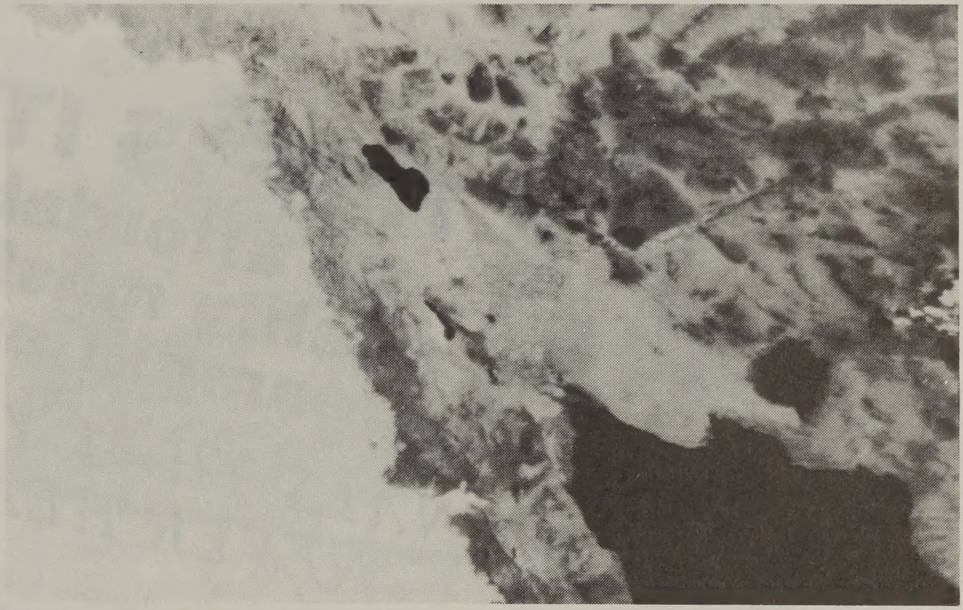


Fig. 4

Fig. 5

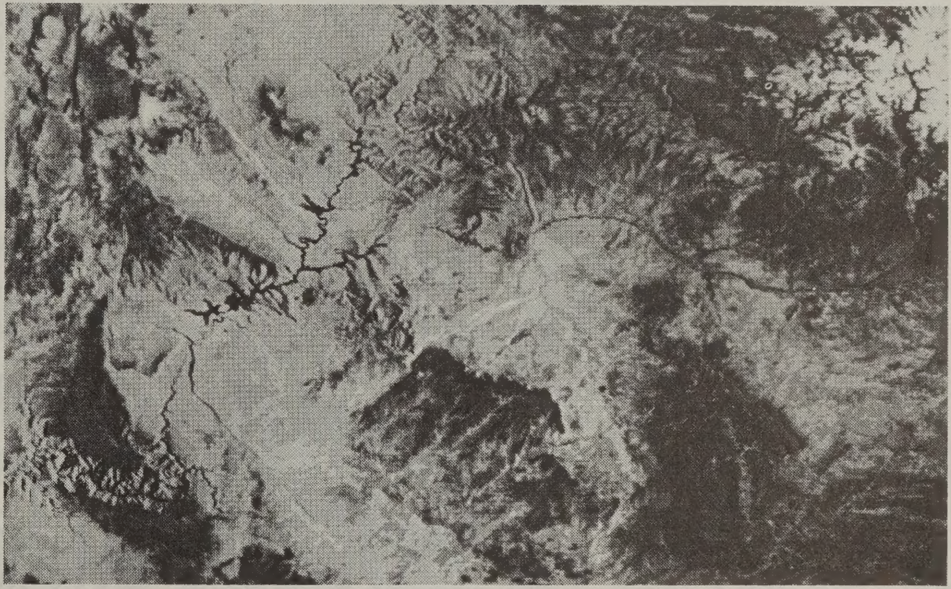
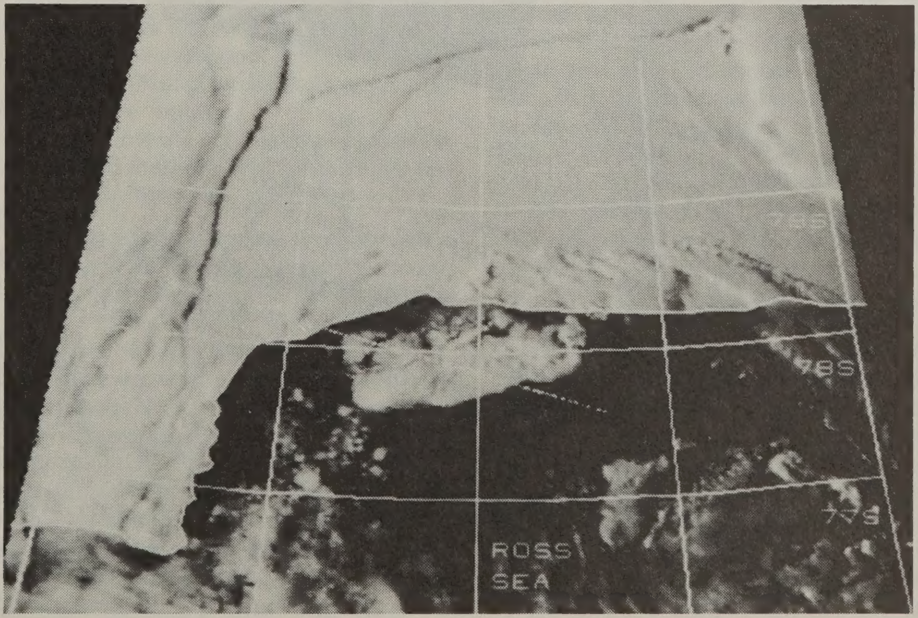


Fig. 6

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HAMS IN SPACE UPDATE

By

Bill Tynan, W3XO

Vice President for Manned Space Programs

Early Plans for a Packet Station in Space

Plans for another Shuttle "ham in space" operation have been underway since well before the Challenger tragedy. The opportunity for another such flight opened when Dr. Ronald Parise, WA4SIR, of Silver Spring, Maryland, was selected as a Payload Specialist to operate the "Astro" equipment on a planned Shuttle mission. The Astro mission, which includes an infrared telescope, was to have been flown in March 1987, just following the ill-fated Challenger launch. As in the case of the previous two NASA approved Amateur operations from the Shuttle; a proposal, seeking authorization for WA4SIR to operate from space, had been jointly prepared by the ARRL and AMSAT, and submitted to NASA headquarters in Washington, DC in early 1986.

From the beginning, Ron's Amateur Radio mission centered around a packet station in space. Prior to the scheduled flight, hardware and software preparations were underway. With Tom Clark, W3IWI, and other AMSAT volunteers taking an active role. Confidence was high that the equipment would be ready on time, however, the cessation of Shuttle flights after the Challenger accident put a damper on Amateur manned space plans and preparations.

Amateur Manned Space Committee Formed

As NASA was preparing to get the Shuttle back in space, the ARRL Board of Directors, recognizing the need for increased and continuing Amateur Radio participation in manned space missions, authorized the establishment of a committee to promote this objective. Appointed to this committee were: Roy Neal, K6DUE, Chairman; Jon Bloom, KE3Z, ARRL HQ Staff; Lou McFadin, W5DID, Johnson Space Center Amateur Radio Club Representative

The writer had the honor of being appointed as a representative of AMSAT.

The establishment of this "SAREX" Committee, as it has been called for want of a better name, has provided a focus for AMSAT's and ARRL's effort in promoting Amateur Radio on manned space missions. It serves particularly well as a management tool to coordinate the work of many volunteers who may not necessarily be affiliated with AMSAT or even ARRL. It has been in the activities of this committee that most of my work as AMSAT's VP for Manned Space Programs is now centered. I feel that this is entirely appropriate since AMSAT and ARRL have always worked closely with one another, especially in the area of manned space. The proposals for all Amateur operations from space, so far approved by NASA, have been prepared and submitted jointly by both organizations.

SAREX Committee Activities

The first formal meeting of the SAREX (Shuttle Amateur Radio Experiment) Committee took place in August 1988 at the Johnson Space Center in Houston. At this meeting the committee dealt first with enunciating a set of broad objectives for Amateur Radio's role in manned space. With some editorial license, these can be summarized as follows:

1. Promote interest among young people in science and technology and space in particular.
2. Promote a positive image for Amateur Radio and interest new people in the hobby.
3. Provide new operating opportunities and challenges for Earthbound Amateurs.
4. Provide recreational opportunities for astronauts. (This is particularly applicable to the Space Station.)
5. Demonstrate various communication modes and methods which may have application in the space program.

In support of these general objectives, it was agreed that we would attempt to include a new experiment on each flight in which Amateur Radio participates.

Another of the group's major tasks at its initial meeting was identifying work needed to obtain NASA approval for ham participation on WA4SIR's flight, which had been designated as STS-35. This became critical, when it was learned from NASA officials attending the meeting, that SAREX was not manifested on that flight. As a part of our effort to secure approval, the Committee established a specific set of Amateur related experiments which it thought should be included on STS-35. These were as follows:

1. Retain the capability for 2 meter FM two-way voice communication. It was felt that this is very important because of the high impact that voice from space has on lay people, especially youngsters.
2. Retain the capability, demonstrated on WØORE's flight, to exchange slow scan TV pictures between the Shuttle and ground stations. It was agreed that the addition of pictures has significant impact particularly in post flight documentaries such as the video presentations produced by ARRL.
3. Add packet capability with several modes of operation. It was agreed that packet should be tried from space as it would enable many additional successful QSOs and because it could demonstrate the capability of the mode to NASA officials.
4. Add an experiment to demonstrate the capability of transmitting fast scan TV (FSTV) pictures from designated ground stations to the Shuttle. One of the incentives for including this mode was that FSTV has not yet been sent up to a spacecraft, thus Amateur Radio might be able to achieve a first, and thus gain additional publicity and prestige.

In light of the distressing information learned about our status with respect to STS-35, the committee recognized the immediate need to send a letter to NASA Headquarters, reaffirming the Amateur community's desire and willingness to participate on the mission. As before, such a letter was jointly prepared and submitted by ARRL and AMSAT.

Equipment Preparation Continues

While awaiting a reply from NASA Headquarters to the ARRL/AMSAT letter, work continued on readying equipment for the flight. Packet and FSTV were new to the SAREX equipment since the WØORE flight and required significant modifications to it. In order to add these two modes to the existing box already housing the Robot slow scan TV converter, Lew McFadin W5DID, and his able associates at the Johnson Space Center Amateur Radio Club, found it necessary to accomplish a considerable amount of repackaging, — among other things to accommodate the small TNC donated by Heath. A larger unit would have probably made the job all but impossible. This repackaging required the use of new, more efficient and much smaller, space rated power supplies. Acquisition of these rather costly units was made possible through a substantial monetary contribution by the ARRL Foundation. A new flight deck window antenna was also needed to facilitate longer periods of operation and accom-

modate FSTV. The single band antenna used on previous flights was mounted in the upper deck overhead window which is often needed for observation, which had precedence. The Motorola Amateur Radio Club in Schaumburg, IL volunteered to design and build a new antenna assembly to include a 70 cm antenna and converter for the FSTV uplink as well as a 2 meter antenna for packet, SSTV and voice. A significant feature of this antenna is that it is capable of being mounted in either of the two flight deck side windows, which are seldom used during the on-orbit portion of Shuttle missions. This should allow nearly continuous operation which is important if the unattended packet modes are to fulfill their full potential.

At the SAREX Committee's second meeting in March 1989, it was reluctantly agreed to not attempt to include the FSTV experiment on the STS-35 mission. This decision was made necessary because of time scale considerations in readying the necessary equipment. It was further agreed, however, that this experiment will be included on a forthcoming flight.

Good News, Bad News And a Long Road Ahead

The good news arrived April 7th of this year in the form of a letter from NASA Headquarters giving a go-ahead for Amateur Radio participation on STS-35, provided that equipment could be made ready in time, accommodated in the available stowage space and that all the necessary paperwork could be generated and approved.

On June 20, the bad news hit. It was learned that the space needed to stow the SAREX equipment, as it existed, would not be available on STS-35. This was because that mission had been extended to 10 days, thus requiring more locker space than usual for essential items such as food. At WA4SIR's suggestion, the Committee agreed that slow scan TV would be eliminated and that the packet TNC, a 12-volt power supply and an accompanying RFI filter would be housed in a small box that could be stowed along with the Motorola hand-held 2 meter transceiver. Another factor contributing to an ability to reduce our stowage requirements to a minimum was an agreement that we could use the back-up Grid computer normally included on Shuttle missions. Once again W5DID and his crew came through and got the repackaging job done. This voice and packet configuration retains one of the Committee's goals of doing something new for each flight in which Amateur Radio participates. Most important, it enables us to get NASA approval for WA4SIR to operate from space on STS-35.

There is still a lot to be done before we can work WA4SIR/Space Mobile, including generation and approval of the mountain of paperwork, referred to earlier, before we can fly. John Nickel, WD5EEV, representing ARRL/AMSAT on SAREX matters at Johnson Space Center, is coordinating much of this effort.

But, There's More

There is a excellent chance of another "ham in space" shortly after Ron's mission, now slated for April 26, 1990. Ken Cameron, a Pilot scheduled to fly on STS-37, has recently passed his Amateur license exam and been issued the call KA5EWP. His success in obtaining a license is a result of the Johnson Space Center Amateur Radio Club's efforts to promote Amateur Radio, especially among the astronauts. NASA Headquarters approval for KA5EWP to operate an Amateur station on STS-37 has been received following submission of still another joint ARRL/AMSAT letter and hopes are high that we can accomplish the things on Ken's mission that we were unable to on STS-35 — including the FSTV uplink experiment.

Keep tuned!

MicroSat Hitchhiker
An Alternative/Adjunct to Phase IV

By
Andrew Reynolds, WD9IYT

Introduction

AMSAT stands on the threshold of a new era of satellite communications. The proposed Phase-4 geostationary satellite will open new possibilities to Amateur satellites users and draw in many who were "put off" by the need to track Low Earth Orbit (LEO) Amateur birds. Phase-4 will be accessible 24 hours a day, seven days a week, probably making it the most-used Amateur satellite ever.

All of this does not come without a price. Phase-4 will be the most costly of all the Amateur satellites built to date. The ease of access will mean crowding is a distinct possibility. Finally, while packet relay will see the inclusion of a package similar to the RUDAK system that failed on AMSAT-OSCAR-13, the system will not be sufficient to handle the amount of traffic that is present for switching across the continent and to other countries. For these reasons, I propose in this paper an alternative that would be made of the following:

1. Dedicated ground stations for the uplinking/downlinking of packets from specific geographic areas.
2. A number of small, MicroSat-based satellites to be carried to geostationary as secondary payload on other satellites going to GEO.

Rational

Geostationary orbit (for brevity to be referred to as GEO) represents an ideal location for a long-haul, high speed packet data relay system. Without the need to await a favorable satellite pass, network throughput increases dramatically, allowing more messages to be passed. The frequencies used in satellite communications, particularly the low microwave frequencies of 1.2 and 2.3 GHz., are well suited to the wide-bandwidth needed for high speed data transmission. Finally, the lack of any tracking of antennas allows a simpler ground station, conceivably completely remote from users, reducing the amount of "computer smarts" such a system would need to function, making it accessible to hams in countries like the USSR where small computers are still hard to come by.

Costs

No system based at GEO is without a major up-front cost: the price of getting there. Traditionally, GEO launches are the most costly, based on the size and cost of the large boosters needed to loft any large payload that high. Even in the new era of commercial space launches, costs are far beyond the reach of AMSAT or any other Amateur satellite group. The situation is unlikely to improve for the foreseeable future, with dedicated launches priced in the $100 million range for many years to come.

Phase-4 attacks the problem of costs by building a satellite into a section of the main payload adapting hardware. This approach is the main reason that AMSAT can even contemplate the Phase-4 project. Even this will not make the ride free. Costs quoted in such publications as *AMSAT Journal* are in the $1 million range. Cheaper than a dedicated launch, true, but a sizable sum of money for any private not-for-profit group. This cost is in addition to the costs of designing and developing the Phase-4 satellite itself, now expected to run in the $100,000 plus area.

My system is termed MicroSat Hitchhiker, as it would attack the cost of launch angle from another direction. Rather than design the Amateur payload into a section of launch hardware, the Hitchhiker would be attached directly to the main payload satellite, to be released when the main satellite deploys itself at GEO. Based on the nominal mass on orbit of a MicroSat of 25 pounds, it should be possible to convince commercial and/or scientific satellite launchers to allow the MicroSat package to "hitch" a ride to GEO on their satellite.

System Overview

A number of systems are now in use in this country and others that could serve as the base of a GEO based satellite packet switching network. Each has advantages and disadvantages:

1. The Tex-Net system is rugged, simple and based on hardware that is both cheap and proven enough to be a known factor in determining probable reliability on orbit. It is also slow as packet switching networks go, operating at only 9600 baud, hardly fast enough to handle large amounts of cross continental traffic.

2. The GRAPES system. While fairly fast (56 Kbaud) and designed to mix directly to a broad-band transverter system (ideal for a satellite-based system) it is not in wide use and as such doesn't have an established "track record" for reliability.

3. Various systems, now operating here and in Japan, with data speeds in the one million bits/second range. Very fast, well capable of handling the load of a worldwide packet switching system.

Down side: huge bandwidth (most of systems operate in the 10 GHz frequency range for just this reason) which could overload frequencies too much for any other use.

At the present time, these systems, plus other combinations of hardware/software, represent the leading edge of packet networking. They point the way that a GEO based system must go to serve its purpose. As the one thing these systems share is change, it would seem best to plan a gradual, evolutionary approach to building the system. Early satellites could be based on a system similar to the Tex-Net to allow for lower cost and less development time. Follow-on satellites could expand on this base and work done around the world to improve the speed of data transmission and increase the throughput of the system. This would also allow the user base to build: as the system becomes more acceptable it will gain more users and the need for higher data transmission rates will justify new, better satellite systems. At the same time, older satellites would be available for the remainder of their lifetime for switching systems that didn't need the quick turnaround time of the higher speed main net.

Problems

GEO, while a desirable place for any spacecraft, is not without its hazards. Chief among these is the high radiation flux from the Sun. Satellites in lower orbits, even those in Molniya type orbits, spend most of their time inside the protection of the Earth's magnetic field. This affords them protection from most of the high-energy charged particles of the solar wind. Satellites in GEO orbit are outside this protective blanket and as such must be designed with an eye to the effects this onslaught of radiation will have on the satellite and its electronics. As physically shielding the circuits would add far too much to the weight of the satellite to make it practical, usual design revolves around using radiation hardened components. As any GEO based packet data satellite would be based heavily on electronics, radiation hardness would be a must. Reliable radiation hardening of VLSI chips, like microprocessors, is still more of an art than a science. At present, the most widely available microchips that meet these tolerances are 8-bit processors. The tighter packing entailed in the more advanced 16-bit chips still does not lend itself to radiation hardening. This dictates that first-

generation high speed packet modems will be based on 8-bit technology, a further reason for starting out with systems like the Tex-Net units. Most are built around the Z-80 microprocessor, that, as far as I can find out, is not available as a radiation hardened unit. However, Harris has had available for several years a radiation hardened version of the Intel 8085 microprocessor chip, that runs a subset of the Z-80's micro code. Cross compilers are available to allow more or less direct conversion from existing firmware to match a system redesigned around an 8085. As much of the circuitry outside of the microprocessor is only to MSI standards, and less susceptible to radiation effects, it should be possible to use an almost identical circuit design, allowing for needed changes from the Z-80 to 8085 chips. An exception to this are RAM and ROM chips, which are available from several companies to radiation hardened specifications in pin-for-pin compatible carriers.

As now designed, the MicroSat is literally a flying computer. The entire housekeeping routine is designed to be run by an on-board computer. As this system was designed around a 8088 derived microchip, which is not available as a radiation tolerant part, this presents some fundamental design decisions that must be made. A large part of the present computing power is devoted to the MicroSat's "store and forward" ability, which would not be needed in a digital switching system. Provisions for bulletin storage and posting would be very useful, though, but could be accomplished with simpler 8-bit processor technology. Other functions, such as spacecraft temperature, battery status, and other satellite systems could be similarly monitored and controlled. As a side light, with the almost constant sunlight available at GEO, battery requirements would be greatly reduced from that needed for a similar mission in LEO. With the need to carry the on-board systems through only one or two hours without power every six months, battery power and regulation could be greatly simplified. A base system might only carry enough battery power to carry on-board systems software and bulletins through an eclipse, with the transmitter receiving power directly from the solar cell subsystems. The details of this and other possible changes should be looked into.

A second problem is the rather ticklish one of finding a "donor". While 25 pounds is not in itself a huge amount of weight, in the GEO communications field, weight is everything. As the weight of the MicroSat Hitchhiker would have to be "made up" somewhere else, and satellites going to GEO are already made as light as possible, there are few places that the extra allowance can come from. Most likely would be a reduced maneuvering fuel load, which would cut into the lifetime of the main satellite. Other areas (reduced weight in adaptor hardware for example) hold less promise of weight savings. Based on an assumption that fuel will be the only possible area of savings, the question must be asked: Who pays the difference in operating revenues? If AMSAT is to bear the full force of this cost, it would make a MicroSat Hitchhiker as expensive as the Phase-4, if not more so!

There are several avenues of attack, though. AMSAT could negotiate a partial payment for lost time. This would probably be the most difficult option, and the most expensive, but it could be done. A second option is to negotiate launch services as an "in kind" service, to be claimed as a tax deduction, AMSAT being a not-for-profit organization. This should be explored first, as it will involve only the cost of researching the applicable laws and negotiating the deal. The down side is that this option is basically open only when dealing with US based firms, as they are the only ones that these laws apply to. This cuts out quite a few possible launch options. A third option would be an information transfer contract. AMSAT would trade details of the systems developed for the Hitchhiker for launch options. Several companies have recently expressed interest in smaller satellites, and they may be open to an even swap.

Conclusions

If the history of AMSAT and satellite systems in general teach us anything, it is that it is never a good idea to pin all of your options on one system, worse on one satellite. By virtue of its cost alone, Phase-4 will move AMSAT in just that direction. It is the main focus of AMSAT planning beyond the MicroSat program. Some consideration has been given to the idea of producing another of the Phase-3 type satellites, and this has much merit. However, AMSAT will eventually decide to move into the GEO field, and before it does, it should examine all the possible routes to getting there. I think, and I hope this paper has shown why, that the MicroSat design can serve as a low-cost alternative to Phase-4.

To commence a study of this option would be fairly inexpensive. The basic design for all the systems has already been done, leaving only those subsystems that are specific to the Hitchhiker program to be studied. I feel that the funds AMSAT might spend on such a study would be well spent, and the members well served by such an undertaking.

AMSAT-NA PHASE IV PROJECT
Lessons in Distributed Engineering

By
Dick Jansson, WD4FAB
Asst. Vice President, Engineering

The academic year 1988-89 has provided AMSAT with some really new experiences in engineering and fabricating a moderately large ''small satellite''. While most of the AMSAT engineering forces were engaged in a truly small ''small satellite'' — the MicroSat Project — a few of us have been engaged in the Phase-4 project in conjunction with Weber State College (WSC), a new working environment for AMSAT.

This experience has provided us with insights on what kinds of tasks that we can expect to assign and be completed. We know that the basic planning, task descriptions, people interfaces and organizational interfaces are different from our prior experience with an all-volunteer operation. Through a recounting of these experiences, it is hoped that insights in working in this atmosphere will be passed on to those who need to conduct future satellite projects in the academic arena.

Introduction

The effective conduct of a satellite design and construction project involves many non-engineering aspects. Such programs in a commercial or governmental environment are conducted under a set of organizational work rules that follow well established patterns. AMSAT has built and orbited small satellites for a number of years and we have done so under considerably different work rules that those typically seen in commercial establishments.

An even different satellite construction environment has been experienced in our teaming with WSC for the fabrication of the AMSAT-NA Phase-4 spacecraft model. A study of the implications of this people-to-people interaction is useful so that we can capitalize on the positive aspects of this relationship. Concurrently, we need to avoid those traps which would otherwise cause the project to have a less than desired output.

Conventional Processes

Performing engineering tasks, such as the design and fabrication of small satellites, in commercial or governmental workplaces, is done under organizational patterns that promote appropriate divisions of authority and responsibility, Figure 1, left side. Worker control, communications and motivational rewards are well established and generally provide smooth operating results. Leaders, such as Program Managers (PM) and Project Engineers (PE) are able to achieve program objectives by motivating workers through conventional means of job satisfaction and wage rewards.

Very often an organization needs the services of other entities to achieve the program objectives. The contracting organization then becomes the ''Customer'' and obtains the needed services of the ''Vendor'' through a process using one or another form of a contract, the tie that binds. In these relationships, inter-organizational communications must be conducted through the contractual ''pipeline'', so that those employees responsible for the contract can maintain a reasonable control of that contract and its costs. There is, generally, an inhibition about communications and other inter-organizational activities that are not done through those responsible for the contract. This process is only one of good business sense and is often referred to as a single-point-of-contact, within each organization.

AMSAT Projects

For a couple of decades AMSAT has spearheaded the design, construction, and operation of small satellites for Amateur Radio communications purposes. This has been done even though there was a total lack of interest in the aerospace industry in truly ''small satellites''. Academically, that lack of interest vanished when the US Government became interested in the value of small satellites, and now it seems that everyone is interested in small satellites.

The Radio Amateur Satellite Corporation, also known as AMSAT, is incorporated as a 501(c)(3) nonprofit, scientific and educational organization for the purposes of constructing and operating Amateur Radio satellites. This is a lean operation with only a single employee (an Office Manager) and depends upon the efforts of volunteers for its outputs. Gone are the common workplace motivational rewards of wages, gone is the conventional job-control hierarchical structure, and also gone are the close-in face-to-face communications of an organization located in a single facility. Still remaining in this AMSAT operation, though, are the rewards of ''job satisfaction'', as that reward is the principle motivator for a volunteer worker.

Figure 2 illustrates this AMSAT Project way of life, substituting dashed lines, for the communications and controls applied to volunteer motivation, in place of the solid lines of direct employee control, previously shown in Figure 1. This AMSAT process also shows several other significant elements, discussed forthwith.

As we are employing the services of volunteers from across the North American continent, and even from abroad, we need ready, efficient and cost effective communications. These communications have been found to be best served through the facilities of a commercial ''Electronic Mail'' bulletin board system (BBS). While electronic mail serves the function well and with expediency, it is, again, no better than how effectively the volunteer makes use of the facility. If a volunteer does not frequently check his mail, the communications system fails and the leaders must resort to more costly telephone services to achieve the needed communications.

Volunteer efforts are most often focus-

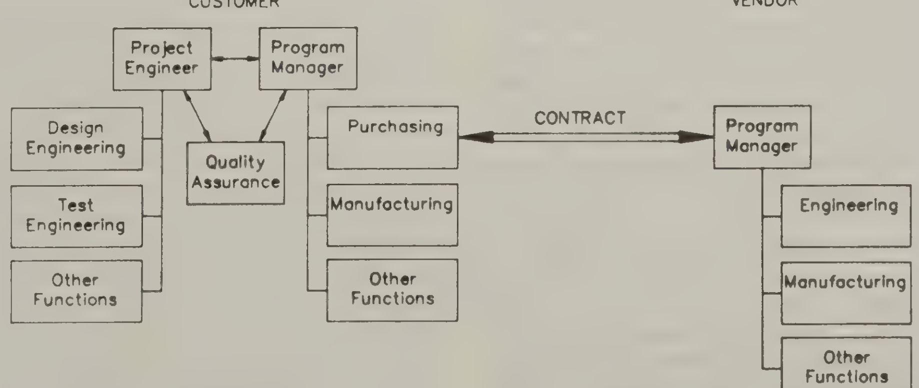


Fig. 1

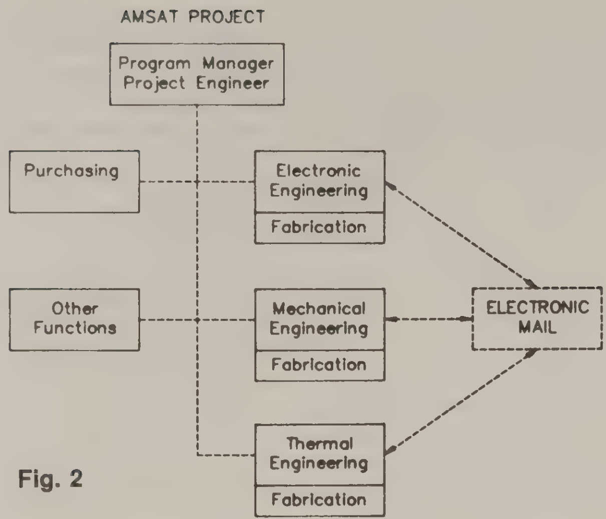


Fig. 2

structure similar to those found in commercial workplaces, with a "Student Leader" for the project, and with the help of a number of "Group Leaders" as befits the magnitude of the project. Each Group will undertake only a portion of a project so that the whole project work load is (more or less) uniformly divided among the entire group of students assigned to the project.

ed and led by a single operating entity, or individual, the combined Program Manager and Project Engineer (PM/PE). Though this type of combination is not foreign to commercial organizations, it is not commonly practiced on modest to large projects. AMSAT does not have a surplus of qualified and motivated personnel to be able to afford separate PMs and PEs on its projects.

Another different aspect of an AMSAT project is that we do not have a single manufacturing facility. The individual designer must resort to the fabrication of the outputs of his creation in his own locale, be it his home or that of a nearby supporter. In the previous millennia the AMSAT assembly process would have been called a "Cottage Industry". As an example, whole electronic assemblies are made in the Washington, DC area, computers in Arizona and California, power supplies in Connecticut, specialized molded components in Florida, battery selections in Ottawa, Canada, and insulation blankets in Florida or Colorado. With this spatial diversity for designing and fabricating spacecraft assemblies, it is amazing to many that anything actually gets built, much less into orbit.

On the face of it, the AMSAT process may seem totally unwieldy and without reasonable controls. The key elements to the success of these projects depends upon the skilled dedication of a few leaders who will fearlessly motivate the volunteer corps to actions that are in step with the program needs. On the down side of this process is that the personal price paid by these same few leaders can be unacceptable and unbearable to many.

The Weber State College Process

WSC in Ogden, UT, is a four-year technology college offering degrees in various engineering "technologies" as opposed to engineering "degrees", for whatever that distinction means. Each senior student in the School of Technology is required to apply himself/herself to a "Senior Project" of 300 hours of effort. The senior project process, thereby, provides a labor base for projects of common interest to the school and students. Senior projects are monitored and controlled through the typical Instructor/Student relationship, the solid connecting lines on the right of Figure 3.

The objective of the senior engineering technology program is to round out the student's education with a project that will let the student apply all of the academically acquired knowledge into a team effort simulating an industry environment. The project must be well chosen such that the students can be assured a reasonable chance of success and yet extend and challenge the student's capabilities.

A senior project has an organizational structure similar to those found in commercial workplaces, with a "Student Leader" for the project, and with the help of a number of "Group Leaders" as befits the magnitude of the project. Each Group will undertake only a portion of a project so that the whole project work load is (more or less) uniformly divided among the entire group of students assigned to the project.

A technology "Center of Excellence" facility is also located at WSC in the form of the Center for AeroSpace Technology, CAST. CAST's role in life is to assist the enhancement and expansion of aerospace technology-based business activities that have meaning to the State of Utah. One of the tools at CAST's disposal is the student Senior Project labor base. CAST also encourages the participation of technologically specialized volunteers in this student senior project process, thereby gaining the direct inputs of practicing professionals. As with other volunteer communication links shown in these illustrations, these CAST volunteer links to the students are by the dashed lines shown.

As with AMSAT projects, the organization of any one Senior Project may seem rather loose and unfocused, certainly in reference to the close project structure seen in commercial workplaces. Marrying an AMSAT project with the WSC Senior Project through the CAST operation could be chaotic.

The AMSAT Phase-4 Project at Weber State College

Directing our attention to the one-year experience of the AMSAT Phase-4 pro-

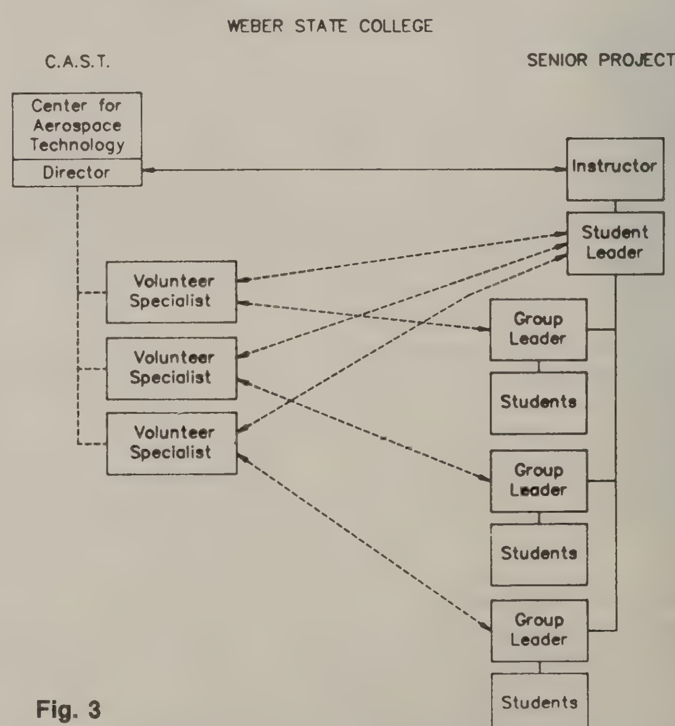


Fig. 3

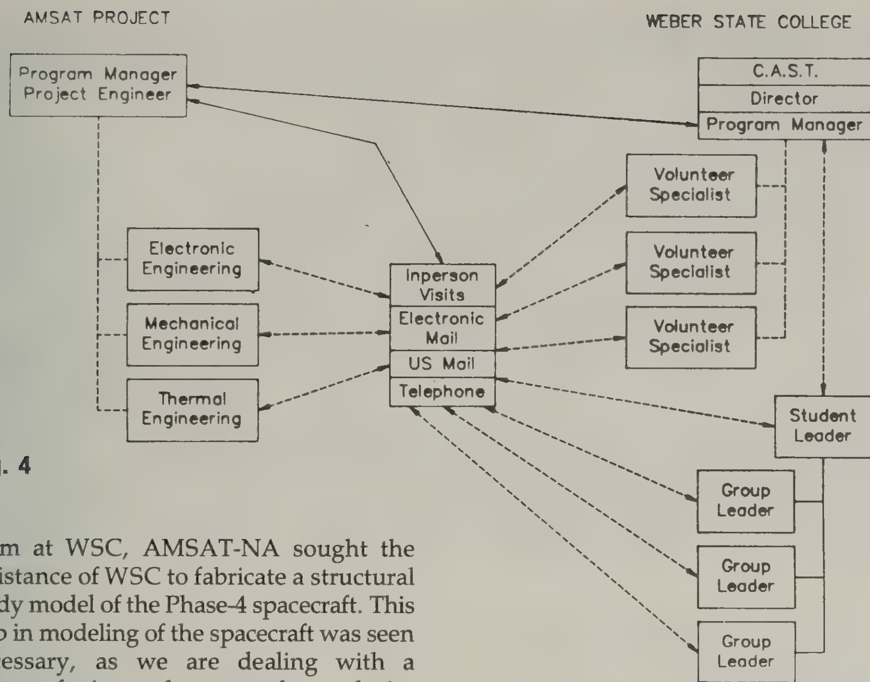


Fig. 4

gram at WSC, AMSAT-NA sought the assistance of WSC to fabricate a structural study model of the Phase-4 spacecraft. This step in modeling of the spacecraft was seen necessary, as we are dealing with a spacecraft size and structural complexity that is outside our prior experience and we needed to employ materials technologies that are new to AMSAT. WSC, in turn views Phase-4 as a very good student training tool for the Senior Project participants. Even the ''new'' relationship of dealing with an ''outside'' organization was viewed as a good experience for those students.

The projects chosen in the past, in engineering technology at WSC, have been totally conceived, designed and managed by student, faculty and local volunteer engineers. This process provided easy communication paths and a direct management chain to solve problems.

The opportunity to work jointly with AMSAT in satellite development programs added a new dimension of challenges for the local management team. AMSAT has worked for many years in a geographically distributed engineering mode. This joint AMSAT/WSC effort would decentralize the design and management efforts used in past WSC projects, but added great depth in engineering skills and exciting new project challenges from AMSAT. It was anticipated that the decentralized management would make the project more difficult, but the added benefit for the students would more than offset this difficulty.

The following is a summary of the findings of this one-year experience in dealing with the WSC as a ''Vendor'', a term that loses its applicability in this relationship. We have found that the conventional process in which ''Customer'' designs devices, and for them to be blindly fabricated by the ''Vendor'' does not work in the AMSAT/WSC effort and the terms inappropriate. A more suitable description of the AMSAT/WSC relationship is as ''team members''.

In the construction of a device, the basic design objectives, specified by the AMSAT drawings needs to be met, but the process of getting to that point of the fabrication is subject to the tools that are available at WSC (and they are good, too) and to the design-fabrication reviews by the students. Student suggestions for design modifications to ease fabrication were valuable inputs, and provided a degree of feedback to the design that is different and more free than has been experienced in industry. Student innovation was encouraged by both WSC and AMSAT, although this innovative process could not be allowed to run unchecked. These processes, Figure 4, must involve the whole range of modern communications techniques, a new element for the WSC/CAST participants.

In the AMSAT/WSC arrangement originally implemented, CAST supplied a Program Manager to guide the student efforts from the CAST view point (a function different from that of the academic instructor). This PM was intended to be the single point of contact with his AMSAT counterpart, and the information flow would then spread out to the student groups. The dedication and time requirements placed upon the PM, especially in the close interfacing with student groups, created a large burden upon this individual and the PM had difficulties functioning in accordance with the program needs.

With WSC performing work for AMSAT, strict budget allocations were required for each task undertaken. In addition to the student leaders, previously noted, one student was also selected as a purchasing director and had the responsibility to monitor all purchases for each team. To maintain further monetary control, each major purchase had to be approved by the AMSAT project director. This communications was accomplished by use of an electronic mail system for quick review and the regular mail for signed document approvals.

The students met weekly for program progress reviews with faculty and local engineers. Notes from this meeting were compiled and sent to the AMSAT project director for review.

In this AMSAT/WSC relationship, another heavy emphasis is placed upon the CAST volunteer specialists, as they are expected to provide technological inputs and continuity for the student groups. In a number of cases the CAST volunteers have also been incorporated into the AMSAT project structure, making the separation between the two organizations (at least from the viewpoint of the CAST volunteer) rather indistinct. This blending of the volunteer corps is viewed as good for both organizations and there have not been any negative aspects to that conjunction.

As the Phase-4 model construction effort evolved at WSC, it was found that the involvement of the AMSAT PM/PE was substantially increased, more so than had been anticipated at the start of the program. Some of this additional involvement was a result of the problems in the CAST PM operations, but more of the involvement was the result of the effects on the design by the innovations of the students. This student innovation activity could not be discouraged as it resulted in substantial cost savings and the completion of some elements of the model that had not been planned to be fabricated in this phase of the effort. An example of the innovation was the Adaptor Cone, which is anticipated to be of carbon fiber composite material, an undertaking not warranted at this time. Instead, the students fabricated a skin-rib Adaptor Cone that filled the needs of the model quite well. Another example is the key structural spacecraft element, the Top Plate. This Top Plate had been planned to be a custom formed aluminum honeycomb sandwich. The students found that such a panel would be prohibitively expensive whereas they could purchase 4'x8' standard panels with the proper skin thickness. An abutting joining process was evolved with the students to form the single panel from two standard pieces, a process that will probably find its way into a flight design.

As a result of the interactions between the AMSAT distributed engineering efforts and the fabrication efforts in Ogden, every conceivable form of communications was employed in this past year, as indicated by the central box of Figure 4. These communications formed the central hub of a very complex network of person-to-person linkages amongst all parties, and are the key to a successful functioning of a design/construction teaming across con-

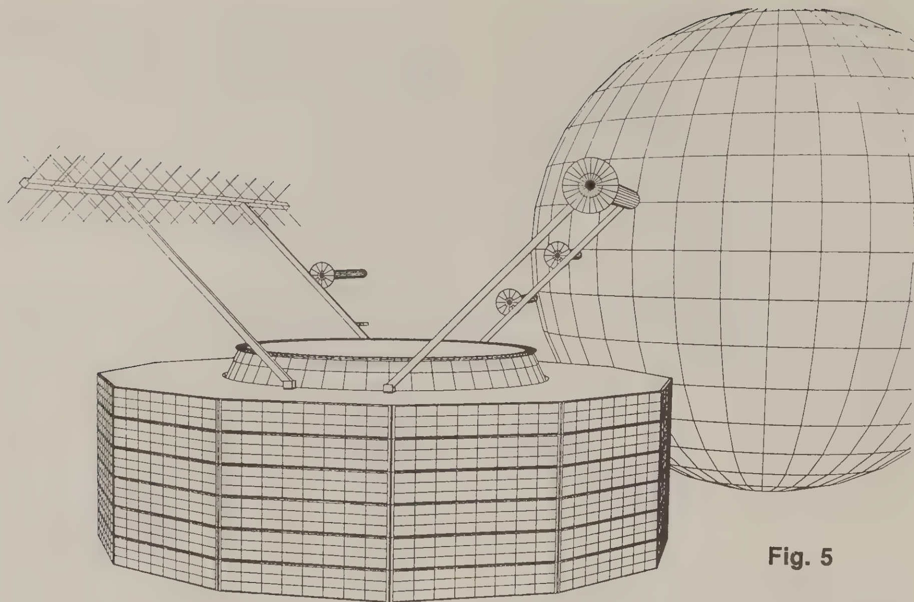


Fig. 5

tinental distances.

Program Advantages

The new relationship with AMSAT provided a greater degree of interest for the students in working on a project to the specifications for a customer outside WSC. Quarterly reviews by the AMSAT project director provided valuable mass updates for the students as compared to the electronic mail and telephone conversations.

The project in building the first engineering model of the AMSAT Phase-4 geostationary satellite proved to be an exciting and challenging opportunity for students. There was constant exchange of new design and fabrication ideas between the students and AMSAT.

AMSAT received its first engineering model at a cost of less than $8,000 for materials. A savings of almost $3,000 from the projected cost at the beginning of the project. The model has proved to be a good public relations asset for AMSAT and WSC.

Program Disadvantages

The difficulties encountered in this new program management approach was most difficult on the WSC faculty, senior projects program manager and the local engineers. The faculty and local engineers suffered a degree of frustration in not having complete control in the design and fabrication decisions. This lack of participation or feeling of contribution lead to the loss of some of the past local volunteer engineering talents.

The long distance communication and distributed project monetary control added additional project management work loads that past, locally originated projects did not have.

Only those tasks that were very explicitly defined at the beginning of the project were completed successfully. Some tasks were undertaken and not completed due to the lack of technical and management resources both locally and from AMSAT.

Lessons Learned

The lessons learned from the joint development programs with AMSAT has shown that the benefit to the students is much greater than with locally conceived and managed projects. This greater benefit to the student requires that the program management at WSC must be better prepared before the program begins by:

Having the tasks well defined at the program start such that major hardware accomplishments can be made by the students.

Selecting local engineers that can gain satisfaction in participation where the design and fabrication efforts can be a joint effort of local and distant AMSAT engineers.

Increasing the frequency of visits by AMSAT engineering representatives, permitting concentrated problem solving sessions with the WSC students.

Providing an opportunity for the AMSAT engineers to share their experience and talents in formal classes for students.

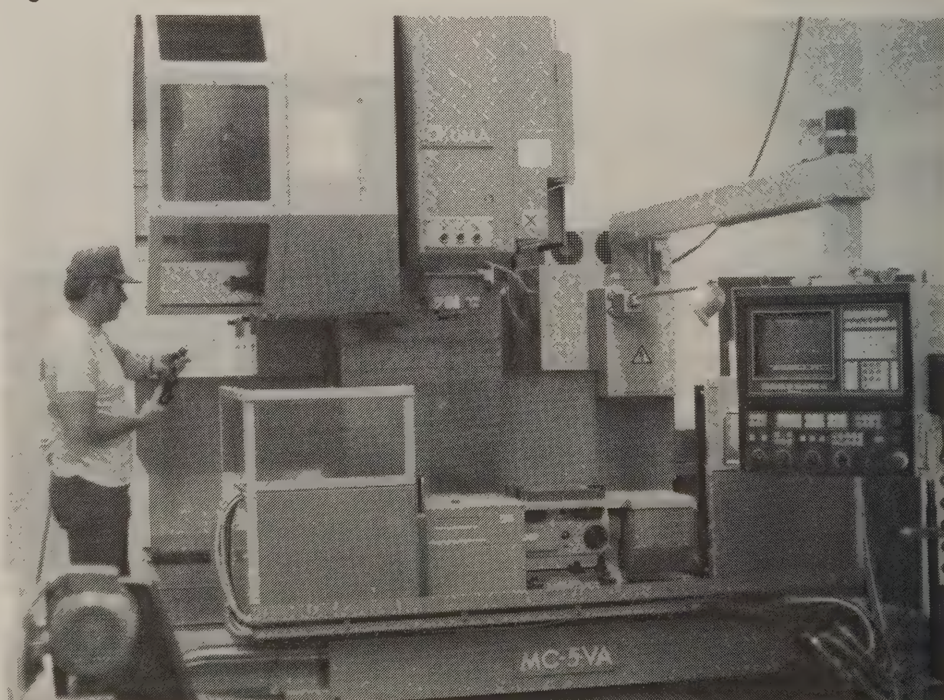
Providing monetary control on more general purchases rather than detailed items.

Phase-4 Structural Study Model

A discussion of the details of the Phase-4 structural study model is outside of the context of this paper. Some illustrations of the student efforts should suffice to convey that the AMSAT/WSC teamed program effort was a success. Figure 5 is a CAD illustration of the flight configuration of the Phase-4 spacecraft in orbit, and is provided as a reference for the illustrations to follow.

Numerical machine tools were extensively employed for the Phase-4 fabrication, Figure 6. Figure 7 illustrates two items of student/CAST-volunteer innovation. The ring, which in a flight configuration is a 1.9 Meter diameter single piece aluminum machining. This version was constructed by the students in twelve sections and bolted together. A second item of interest is that an assembly fixture plate was needed to locate spacecraft components for the assembly and the 8′x8′ steel plate on

Fig. 6



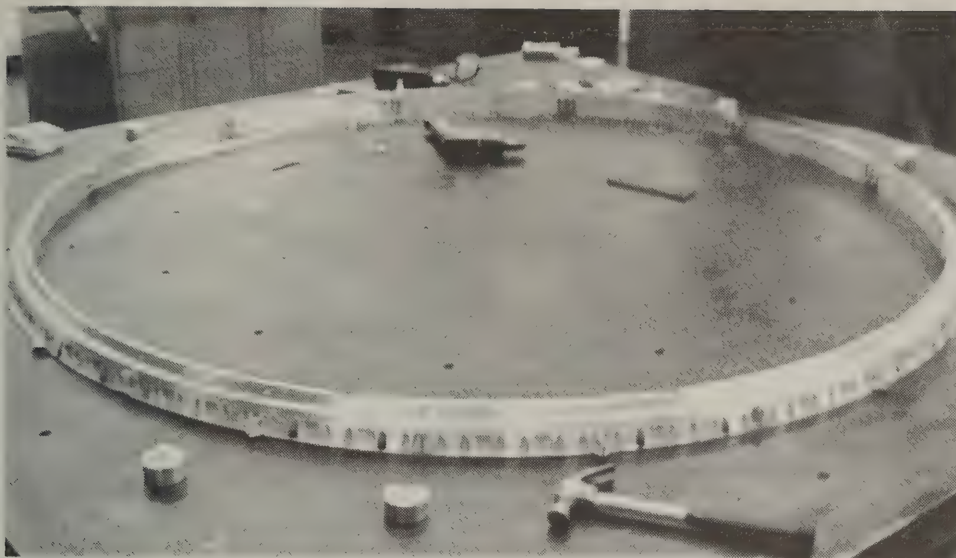


Fig. 7

Fig. 8

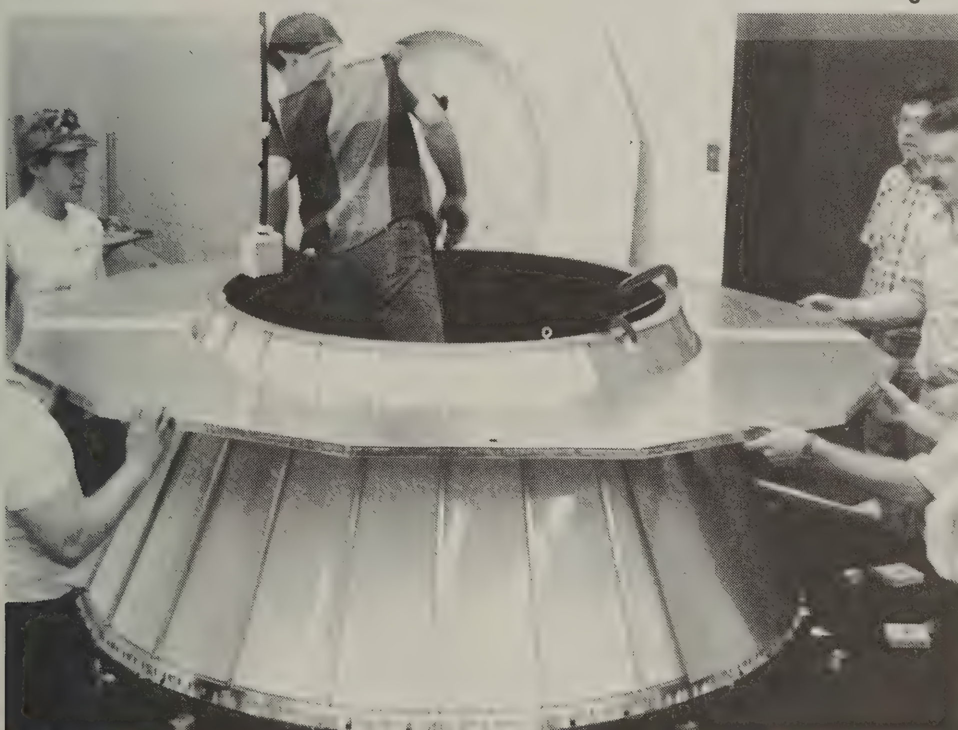
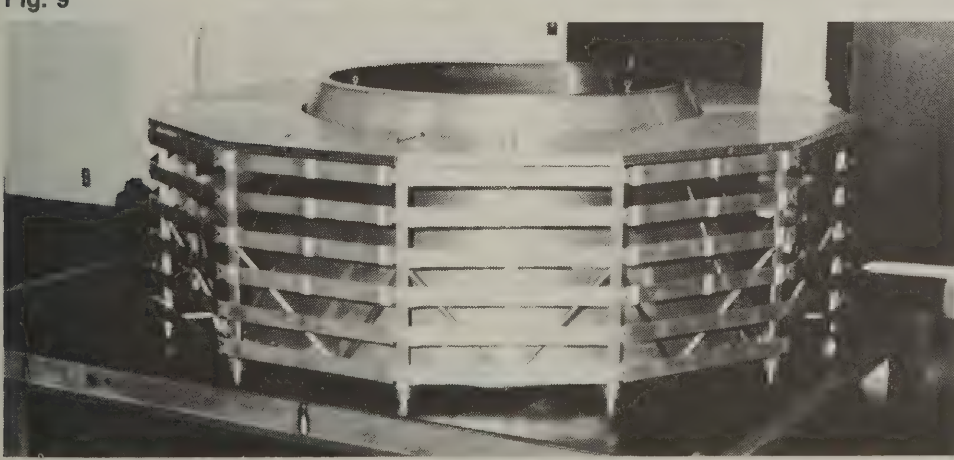


Fig. 9



beams satisfied that need very well. Figure 8 shows the partially completed Adaptor Cone and the Top Plate being check fitted by the students. This group of students does not appear to be too unhappy in their labors. Figure 9 displays the spacecraft model without its simulated solar panels.

Phase-4 Program Conduct for Academic year 1989-90

From our experience of the past year, it is clear that the personal contact with the students is exceedingly important to the conduct of the program. It is almost immaterial whether that contact originates from CAST or from AMSAT, the point being that the contacts are needed. Students need to be attracted to the program so that they will commit themselves to it for their Senior project. This effort to attract students is different to that of attracting volunteers to CAST or AMSAT, whose participation in the program was a result of the individual's interest in the program in the beginning.

The students are semi-captive participants in a project, in that while they may have some choices in which project they select for their senior year, the breadth of choices are limited. We must motivate and attract students for both their learning activities and a willingness to deliver a quality output. Similarly, WSC instructors need to be attracted to participating in details of the project, another form of volunteerism, which is very important as their interest and enthusiasm for the project is felt into the student ranks.

Conclusions

The additional effort required to manage this distributed engineering program with technology students provides significant benefits to the education of the students and gives AMSAT a bargain of over 500 hours of local engineering labor, nearly 4000 hours of student labor and the use of over $500k worth of CAD/CAM equipment.

Acknowledgements

It is only fitting to give credit where it is due. Obviously this effort represents the product of many persons, but two of these are notable in this AMSAT/WSC relationship. Firstly, I want to thank Bill Clapp, of WSC, for his initiation of the AMSAT ties to Weber State College and making it happen. The biggest thanks go to Bob Twiggs for his enthusiasm and support for this project and his bullet proof hide, resistant to the barbs continually sent his way, while he keeps on smiling and supporting.

This paper was first presented at the "3rd Utah State University Conference on Small Satellites", Logan, UT, 26 September 1989.

AMSAT OPERATIONS FOR 1989 & 1990

By
Courtney Duncan, N5BF
AMSAT-NA Vice President, Operations

During the past year the Amateur satellite community has experienced two major events: the first full year of operation of AMSAT-OSCAR-13, the first Phase-3 satellite to be fully deployed, and preparation for a new era with the imminent launch of four MicroSats along with two new UoSATs. These serve two overlapping constituencies. AMSAT Operations is in the midst of developing programs to fill out one and to prepare for the other.

AMSAT satellite development projects are accomplished through a "distributed engineering" approach. Hardware, software, and other contributions come from all over. Coordination is handled mostly via electronic mail and occasional face-to-face meetings. The AMSAT-NA core is a small, highly dedicated and motivated group that has no formal institutional (educational or commercial) support. This distinguishes AMSAT-NA from the other AMSATs of the world that build satellites.

The tasks at AMSAT-NA Operations contribute to making use of the satellites once in orbit and providing technical and information support to the ground based operators. It is my goal to perform these tasks as organized, distributed efforts in much the same way that the satellites themselves are developed and deployed. The hemispherical coverage of AMSAT-OSCAR-13 and electronic mail PACSATs go a long way toward making this possible for a large group of modestly equipped but motivated satellite users.

When I was appointed AMSAT-NA Vice President of Technical Operations last fall, then later elected by the Board of Directors to be Vice President of Operations (a position required by the bylaws), I took stock of facilities and programs at AMSAT and made up a list of projects that we could and should undertake from the ground based side. As time passed, other issues arose modifying the list. This paper is a status report, a vision for how to proceed, and a plea for help. Right now, the task list goes as follows, roughly prioritized. A brief synopsis of each is given below.

1. MicroSat Command Network
2. Nets
3. Command Station Development Program
4. Frequency Coordination and Allocation Issues
5. Techno Sports — SatFoxHunt, ZRO tests
6. Gateways — Digital — Packet Forwarding
7. Gateways — Analog
8. Special Interest Groups
9. Satellite Product Development
10. Interface to Other Organizations
11. Orbital Data Management
12. MicroSat Dynamic Model Study
13. Connections to Other Hobbies

I have the time and energy to fully administrate any three of these items and have done more than that over the past year. Clearly I need help. Those who have the interest in AMSAT to be in attendance at this meeting or who have acquired and are reading this paper are prospective leaders of, or contributors to, each of these programs. There is more here than any one person can do, there are plenty of exciting projects to go around. In my administrative style, I want group leaders and participants to be able to do an important and significant part while dedicating as little as a few hours a week. Please contact me to talk about a meaningful role in any of the listed areas or others that you think are appropriate for AMSAT to pursue.

At next year's Symposium, it would be great to see talks and papers on each of these individual subjects.

MicroSat Command Network

When I was appointed to this position, the only actual "assignment" I was given was to set up a command network for the MicroSats. This has been accomplished, at least for the early shakedown phase. Technically speaking, a command station is not much different than any other MicroSat user station except for software. Some degree of automation is very helpful in both cases, and this is covered below in more detail.

To some it is obvious and to some it is nearly forgotten. The four initial MicroSats belong to and will be operated by four distinct groups of people. The hardware (aside from payload modules) is basically the same and all four units have been constructed basically under contract by AMSAT-NA but the satellite licenses are issued to four different people representing four different organizations in three different countries. AMSAT-Italy is also currently building a MicroSat from AMSAT-NA plans and materials. When it is launched, a fifth interest group and a fourth country will be involved.

Operationally, the MicroSats are as unique as any of the Amateur satellites that came before them. The technology developed by AMSAT-NA for MicroSats makes such satellites available to a much wider base of potential spacecraft builders and operators.

The ground networks for the MicroSats will be in four groups also. It is my intention that these four groups will overlap and provide mutual backup but each of the satellites represents a different project and a different set of interests and therefore a different constituency. Despite their similarities, the four MicroSat missions are bound to be quite different once they are in orbit.

Participants in the Command Station Development Program discussed below, and other interested operators will be doing monitoring duty during the early life of the MicroSats along with the actual command stations. If you are equipped for MicroSat monitoring and do not yet have a prioritized listening assignment and reporting conduit, contact me to get an assignment.

Of course, there are also two UoSATs on this launch. Like their predecessors, they are administered and controlled from the University of Surrey. We will of course also be monitoring these with interest as time and energy allow.

Nets

When Andy MacAllister, WA5ZIB, and I were appointed to AMSAT-NA V. P. User Operations and V. P. Technical Operations positions respectively in September 1988, we started keeping a fairly regular schedule on either AMSAT-OSCAR-13 or 10 in order to keep up to date on what we were doing and to make plans. Early this year we decided to expand this schedule into a Net for all on the satellite who were interested in exchanging information about operating on the satellites. This was really just an acknowledgment and public announcement of what was already happening. Either by invitation or by tuning by as we held our schedules, other stations were already joining and enhancing our talks anyway.

At first, we tried to hold the Net weekly, meeting sometime on Saturday between 5 a.m. Pacific Time and midnight Eastern Time. This approach met with marginal success. Within the AMSAT-OSCAR-13 20.6 day cycle (manifested as about a 10 day repeating pattern of orbits from any particular location), one Net out of three was an unqualified success,

another would occur on a day when there was not a pass covering all of the U. S. at once, and the third would occur during a good pass but at a time with bad pointing angles or other unsatisfactory conditions. Still, check in counts were fair to brisk and information was exchanged. It was intended that AMSAT-OSCAR-10 would provide backup when AMSAT-OSCAR-13 was in a poor position and was used as such a few times but the current AMSAT-OSCAR-10 orbit and months-on months-off operating circumstance does not allow it to provide as much backup as was initially intended. Some early nets were held on AMSAT-OSCAR-10, and one was even held on both AMSAT-OSCAR-13 and AMSAT-OSCAR-10.

When planning the cycle of nets from June through November, I took the orbital pattern into account and scheduled meetings to occur during evening hours (U. S. time) during a pass that was overhead to North America when pointing angles were good. This gives high elevations (and lower susceptibility to manmade noise) to stations in the U. S. and generally good to excellent operating conditions.

The format has been to start with a call-up, take check ins until no more can be heard, then go around sharing comments and questions. A typical Net consists of about three cycles of this pattern. This format is followed rather than the standard hf format (call-up, AMSAT News Service bulletins, check ins) because of the repeater-contact nature of the satellite QSOs. On hf it is more appropriate for the NCS to read bulletins and interact with stations because propagation circumstances define net participants as those who can hear NCS. On the satellite, everyone hears everyone. The Satellite Net is designed to take advantage of this special feature of satellite operation and we intend to exploit this further as experience is gained.

Over 100 different stations have participated in the satellite-based AMSAT Operations Net and an average session has over 20 stations checked in. I act as primary net control station and net manager with help and backup from WA5ZIB, WDØE, WDØHHU, and WØRPK.

Aside from facilitating information exchange, this net has two other important purposes. One is to provide a mechanism for OSCAR satellite users to have regular access to AMSAT-NA leadership. (To this end, several of us try to spend a few hours a week making routine contacts on the satellites as well.) This is now facilitated further by having invited "guest speakers" on each net. By the time of the Symposium, we hope to have hosted W2RS talking about late MIR operations, KØRZ talking about Mode S, and possibly KO5I, AMSAT's President and General Manager.

Satellite positions have allowed nets favoring the U. S. to be held during prime time through the summer and fall. For scheduling and convenience reasons, future nets will also allow simultaneous access (non-prime time unfortunately) to Europe or the Pacific. All stations in view of the satellite during a net session are encouraged to participate.

Indeed, the other and possibly most important reason for instituting this net is as a demonstration that regular, controlled operations can be conducted on the satellites. I would like to see this example followed with other nets for specific purposes. Technical sessions, traffic nets, emergency drills, and operations style nets in other parts of the world are part of the goal. One group already meets quite regularly on AMSAT-OSCAR-13 for DX spotting and working. Please contact me about starting a net if you are interested in doing so formally.

The AMSAT hf nets (managed by Wray Dudley, W8GQW) will be a necessary tool for distributing information and recruiting new satellite operators for many years. We would like, however, to see satellite-based nets supplement and eventually supplant this function.

Command Station Development Program

In order to identify, qualify, and equip people for future assignments in Amateur spacecraft operation, particularly the current and future Amateur MicroSats, the Command Station Development Program was instituted. Participants in the program start by registering with the administrator: Ralph Wallio, WØRPK, 1250 Highway G-24, Indianola, Iowa, 50125. If their application (equipment, experience) is acceptable, they join the program at Level 0.

At this level, the goal is to develop and/or demonstrate capability to copy and interpret telemetry from every currently operating Amateur satellite that sends telemetry. A certificate is provided for the first satisfactory report followed by endorsements for successive satellites. Acquiring telemetry means obtaining the necessary equipment, connecting it, and making it work. Interpreting it means converting the data into engineering or other appropriate units and scanning the sample for any interesting trends or features. Any anomalies uncovered during this routine monitoring work should of course be reported to the appropriate authorities. Interpretation might mean doing research into or trying to obtain information on satellite parameters. Sometimes this data is easily obtained, other times it is not. Participants are expected to take the initiative to obtain the necessary information as required and to share it with the rest of the CSDP group. Those making such contributions are considered favorably in the screening processes.

The purpose for this approach is to provide a respectable goal for serious participants that demonstrates their level of commitment. Also, it gets more people involved in trying to understand satellite operation and prepares graduates into Level 1 to be prepared for well rounded involvement in the Amateur satellite program, not just concentration on one single mission or type of activity.

Qualification at Level 2 means making a significant contribution to a satellite operation program. Examples of such a contribution are:

- Monitoring, quantifying, and analyzing MicroSat memory upsets;
- Following satellite solar cell, BCR, and battery state, understanding power operations;
- Contributing software for enhanced satellite operation, hardware or software for implementation of ground projects;
- Archiving and cataloging data collected by team members;
- Analyzing PACSAT usage patterns on a geographic basis;

Virtually every such project will result in an article being published in an appropriate AMSAT or other publication describing what was done or what was learned.

By the time Level 2 work is completed, published, and certified, CSDP members and leaders will be well acquainted with the individual, his temperament, working habits, quality of work, and capabilities. Assignments into serious satellite maintenance can then be made with confidence that operations will be carried out in the best interests of the Amateur satellite users.

Around two dozen stations are now active in CSDP at Level 0. Some have done some of the Level 1 preparation and are waiting for the certification program to get under way before submitting their work. All stations at all levels will be asked to get involved in early monitoring and evaluation of the four MicroSats.

Frequency Coordination And Allocation Issues

Several times over the past year, I was contacted about frequency allocation and utilization issues. In one instance I was asked to attend a meeting of the Two Meter Amateur Spectrum Management Association, TASMA (the group that manages all utilization of the 2 meter band in southern California) in order to justify selection of AMSAT-OSCAR-13 Mode J uplink frequencies. In another instance I was asked if Amateur satellites made any use of our 2.4 GHz allocation and, if not, could we do so quickly as a spectrum preservation move! Interspersed with communications like this, I monitored and was involved in discussions of the utilization of the now generally popular ten meter band and the satellite allocation therein, and the intra-service coordination and interference problems that we have in the 2 meter satellite band.

All of this exposure led me to a single conclusion: Amateurs are wasting considerable energy squabbling among themselves about overused spectrum while taking for granted that unused allocations elsewhere will ''always be there'' in the future, as if Amateur spectrum were irrevocably granted by divine right or unwanted by other interests just because most of us have no use for it at this time.

It is not true that our allocations are irrevocable. Amateur Radio, as we know it, may not exist ten or even five years from today. I don't believe that either 10 or 2 meters is in danger of being lost from under-use, however. If we don't put significant, wide area, operations on less used Amateur bands and do everything we can to let the communications community know that we are using the frequencies for significant, wide area, politically justifiable purposes, we will wake up one day without the allocations. It is not a question of *if* but of *how soon.*

It is even more alarming that satellite allocations as sub-bands within the Amateur service face the same situation among the other hams. Satellite operators probably represent less than two percent of Amateurs worldwide and yet on 10 and 2 meters, 70 and 23 cm, the satellite sub-bands comprise at least ten percent of the space. Many Amateurs, perhaps a majority, have no interest or concern for satellite operations and some do not hesitate to ignore the fact that the frequencies we use have been set aside for weak signal work.

Worse, most coordination of vhf and uhf allocations has been done on a local, ad hoc basis for many years (as in the case of TASMA, for example). Such groups are accustomed to sovereign, regional authority in land mobile style. When assignments need to be adjusted for some super-local reason (like new satellites), notice is expected months or years in advance so that existing users can be relocated with a minimum of friction. Exact dates of change are also expected. For a new international satellite to just pop up on previously unused frequencies with nearly no previous warning and with the justification that ''we said ten years ago we might use this new sub-band someday'' is at best rude and at worse malicious interference! Spectrum is so crowded in many areas that serious consideration is given to computing when satellites on certain frequencies will be below the horizon locally so that other users can be assigned to the bands during those times.

In terms of getting the 2 meter sub-band 144.3 to 144.5 MHz reserved for satellite use in southern California, the recommendation from TASMA was to get as many local satellite users as possible together, come to the annual TASMA meeting, and vote in a committee that will hold to our interests at high priority. They are not interested in arguments of international utilization and widespread interference often presented.

At the same time, a large influx of new users on 10 meters wonders why Amateur satellites have 200 kHz of apparently quiet frequencies while they would like more FM channels at the top of the band.

While all this goes on there is an outcry from within the Amateur Satellite Service for ''more Mode A satellites'' like we had in the ''good old days.''

Satellites are expensive to build, launch, and operate. If another country or another AMSAT in the world is putting up satellites that occupy our small piece of 10 meters, and if these satellites are available for Amateur use everywhere, then we do not think it is a prudent use of our very limited resources to put our own satellites in that band, certainly not while 430 MHz, 2.4 GHz, and other prime frequencies are being eyed by greedy commercial interests.

The bottom line is that we must realize that Amateur satellites do not exist in a spectral vacuum in Amateur Radio, nor does Amateur Radio exist in a vacuum among other communications services in the world. We can only maintain our existence in either case by using our allocations in ways that are obviously beneficial to the regulating and other controlling authorities here and around the world.

I support the stand that AMSAT-NA takes explicitly and implicitly in occupying the uhf and microwave bands with our current satellites and in future plans. Every operating Amateur satellite in orbit today (and a month from today) uses 145.8 to 146.0 MHz for an uplink or downlink or both. It is critical today that we plan to alleviate this intra-service interference and protect our claim to other bands by moving major portions of satellite operation up in frequency as soon as possible.

It is my desire that every AMSAT regional and area coordinator be equipped to effectively represent Amateur satellite interests to their local coordinating authorities around North America and that all AMSAT members be familiar with the problems and challenges that we face on this front. To that end, I will be submitting an article to the *AMSAT Journal* discussing our position and how to present it in such a venue.

Techno Sports — SatFoxHunt, ZRO tests

The satellite-based ''techno-sports'' are something that we have been trying to get under way for a few years now. Aside

TECH TALK from ICOM

ICOM

Packeting Via Satellite With ICOM

Packet Radio and OSCAR satellites are two very popular areas of interest among today's amateurs, and their combined operation opens a fascinating new dimension in printed word communications. This unique concept of "computer-to-computer linking" via a flying electronic mailbox or "BBS" was proven highly successful by OSCAR 12, and our upcoming microsatellites will expand those activities significantly. Larger, deluxe-featured OSCAR's like the geostationary Phase IV units (which will also include Packet operations) are still included in amateur radio's space program. Microsats have simply been added because they are more economical to build and easier to launch.

Two of our first micros, PACSAT and LUSAT, will employ a BBS/Packet mailbox with four uplink channels on 2-meters FM and one downlink channel on 70cm SSB. Ground station requirements to operate both these and future satellites are a pair of compact VHF/UHF multi-mode transceivers, two small antennas, a personal computer, and a satellite-compatible modem/TNC (a Manchester-encoded FSK modulator and a BiPhase Shift Keying demodulator). Another microsat, DOVE, will feature SKI TREK'ers monitored on their ICOM handhelds. DOVE's digitalker, however, will be specially orientated for amateur radio use. Tuning in DOVE with ICOM's new IC-2SAT FM handheld will be easy. Program its 24 hour clock to switch the rig on at "orbit time," it reminds you of the action, and it switches itself off after a pass. That's truly today's most intelligent handheld!

Setting up a deluxe and high performance station for both present and future Packet, SSB and FM operation is a cinch with ICOM's top-line equipment. ICOM's IC-275A/H multi-mode 2-meter and IC-475A/H multi-mode 70cm transceivers, for example, incorporate several advanced features for outstanding satellite operations. Dual Direct Digital Synthesized VFO's in each unit assure very low noise reception, ultra-clean transmitted signals, and high speed T/R switching for great Packeting. A rear panel data input socket and front panel DATA switch are also included on both transceivers for convenient single-button shifts between voice and printed modes. Including ICOM's optional AG-25/2-meter and AG-35/70cm mast-mounted GaAsFET preamps adds the perfect finishing touch to this outstanding satellite system.

ICOM manufactures two versions of the IC-275. Units with "A" designations feature an internal AC supply, rear DC socket, and deliver 25 watts output. The IC-275H delivers 100 watts output and the IC-475H is 75 watts output. Each "H" model is powered by ICOM's external PS-55AC supply.

Interfacing the IC-275A/H and IC-475A/H or any other pair of ICOM transceivers with ICOM's optional CT-16 satellite adapter truly makes satellite operations delightful. The downlink transceiver's tuning dial is then used for single knob tuning. When one transceiver is tuned down frequency, the other transceiver automatically shifts up frequency an equal amount to "follow" a satellite's inverting passband (and vice-versa). Additionally, the uplink unit's dial can be readjusted as required for doppler shift compensation. It is fantastic!

Since the CT-16 satellite adapter operates with several ICOM transceivers for mode A, B, J, K and L, a brief switch-setting or "rig specifying" procedure is necessary at its time of installation. Use our accompanying chart or your rig's manuals to determine each transceiver's address, then set the CT-16's switches accordingly. Remember, the CT-16's left switch's address should agree with the transceiver you plug into the CT-16's left socket, and the right switch's address should correspond to that of the rig-connected to the right socket. You are now ready for top-notch satellite action.

If you experience problems, double-check each transceiver's internal addressing switches with this page's figure and reset them as necessary. Remember, too, previous owners of used rigs could have changed internal addresses. If you need further guidance or own a rig not listed in our figure, simply call ICOM's service hotline at (206) 454-7619 for friendly assistance.

Would you like more information on OSCAR's and the new microsatellites? A special edition of ICOM's highly acclaimed newsletter, RADIO NEWS, featuring those topics will soon roll off the press. Send your name and address and a brief description of your activities and interests to: ICOM America, Inc., 2380 - 116th Avenue, N.E., Bellevue, WA 98004 to reserve a free copy. Tell us, also, what topics you would like to see discussed in future ICOM Tech Talks. As always, ICOM stands by your side with a sincere dedication to ensuring that you enjoy all aspects of our super hobby!

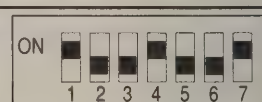
ICOM MODEL NO	TRANSCEIVER'S ADDRESS CODE	CT-16'S RELATED SWITCH SETTINGS 						
IC-275A/H	16	OFF	OFF	OFF	OFF	ON	OFF	OFF
IC-475A/H	20	OFF	OFF	ON	OFF	ON	OFF	OFF
IC-725	40	OFF	OFF	OFF	ON	OFF	ON	OFF
IC-735	4	OFF	OFF	ON	OFF	OFF	OFF	OFF
IC-761	30	OFF	ON	ON	ON	ON	OFF	OFF
IC-765	13	ON	OFF	ON	ON	OFF	OFF	OFF
IC-781	38	OFF	ON	ON	OFF	OFF	ON	OFF
Other ICOM's: Call ICOM Customer Support								

Fig. 1 – Binary addresses of transceivers.

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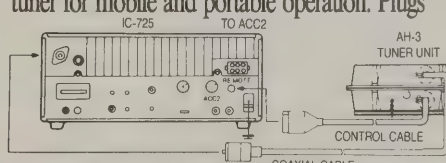

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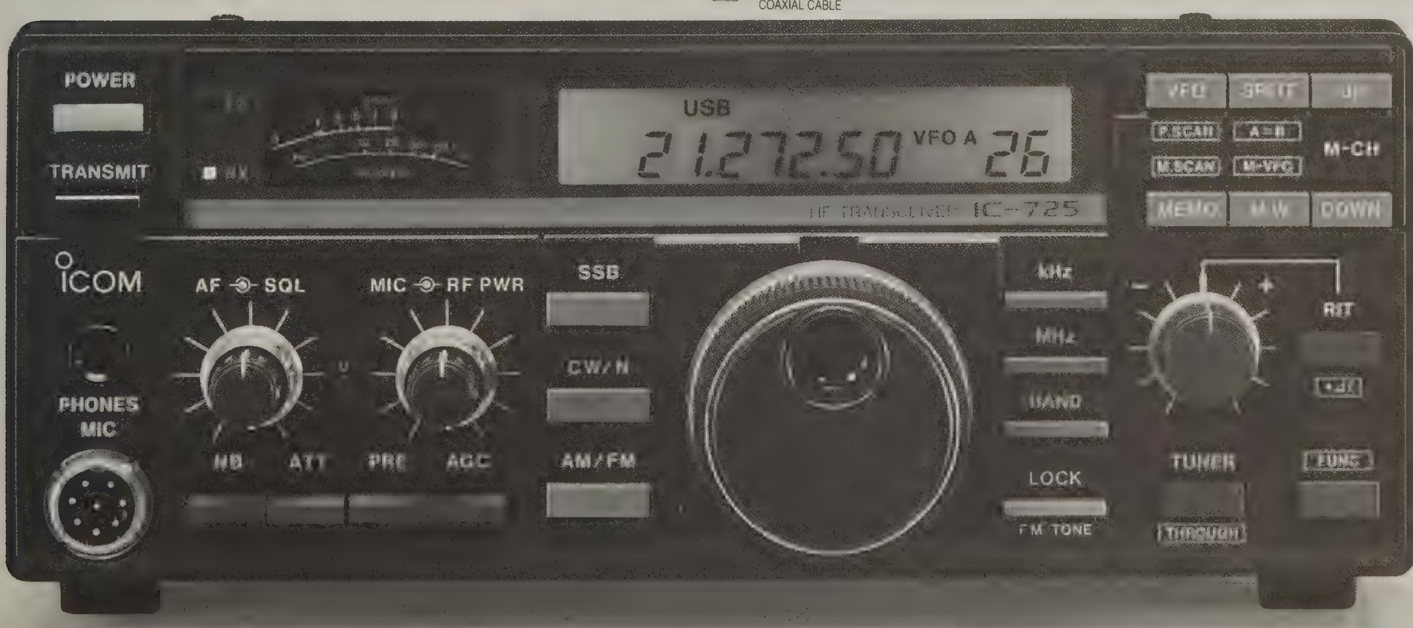

from the resumption of highly successful ZRO tests now held on AMSAT-OSCAR-13, there has not been enough activity in this area in the past year. A techno-sports manager is needed to collect and coordinate information, keep a mailing list, write a few articles describing how to get set up and how things work, schedule tests, and acknowledge results.

Joe Bijou, WB5CCJ (of Silicon Solutions) has provided an IBM-PC based package for post processing satellite doppler shift data. Beta versions of this package are available from AMSAT headquarters. The operator collects and enters satellite beacon received frequencies versus time into a table in a computer file. This file and other data that the program asks for are processed to find the ground location of the monitoring station. An advanced version uses observed frequencies from a satellite transponder carrier along with the known location of the observer to find the location of the transmitter. Ambiguities are possible and the accuracy of the results depends directly on the quality of the satellite ephemeris used, the quality of the observations taken, and the stability of all oscillators involved, on the ground and in space. One second time tag accuracy and one Hertz zero beating for nominal satellites and nominal station radios can yield positional accuracy in the tens of kilometers.

Several hams have built, adapted, or enhanced receiving equipment and computers to collect the necessary data automatically or semiautomatically. One setup developed and coded by Dick Allen, W5SXD, uses a Kenwood TS-790 and a PC with EGA monitor and an AMSAT-TAPR DSP board. This package works well and is accurate but most of the interested hams do not have exactly this setup. Source is provided with the interface package so that it can be adapted to other transceivers. None of the various approaches to data collection have been documented and no group on-the-air tests have yet been held.

Keith Berglund, WB5ZDP, is developing an alternative satellite fox hunting approach which will use time signals, probably from WWV, relayed through a satellite. The data will be the measured difference in reception time between the time standard on hf and via satellite. Software is to be in GWBASIC and may be portable to systems other than the IBM-PC family.

AMSAT-NA Vice President for User Operations Andy MacAllister, WA5ZIB, has undertaken to conduct and certificate the new ZRO tests. Andy runs the Mode B tests and Cliff Buttschardt, W6HDO assists by running the Mode J/L tests. These events have been very popular both here and overseas. Every ZRO test run when the satellite is in view of the Pacific or Europe has spawned a number of foreign entries. A handful of stations have achieved the new Level Z-9, approximately 27 dB below the beacon. Clearly, AMSAT-OSCAR-13 has excellent dynamic response and there is room for improvement in nearly everyone's receiving system.

Gateways — Digital — Packet Forwarding

One of the operational promises of the MicroSats (aside from a full-time orbiting BBS service for satellite operators) is a new forwarding capability for the existing terrestrial Packet BBS network.

Harold Price, NK6K, while in the process of developing MicroSat kernel and application software has proposed an extended and modified protocol for message group forwarding that is particularly fine tuned to PACSAT operating parameters. As time allows during development, both pre-launch and post-launch, these protocols, or some later version of them, will be implemented. Their use will only be effective if compatible, strategically placed ground stations are set up for somewhat autonomous, full time operation. Much of the protocol work, at least in preliminary form, has been published elsewhere recently (such as in the Proceedings of the most recent AMSAT-UK meeting this past summer).

Such ground stations will only be useful if they interact with the PACSATs on a regular basis over long periods of time. Such operation is likely to become very tedious for manual operators very quickly. This leads to the need for fairly robust automation hardware and software for PACSAT digital gateway stations.

Chances are that these gateways will ordinarily exist in support of local PBBSs around the country, not as integral parts of them. A digital satellite operator and an existing PBBS operator will cooperate to bring the new capability about. The digital satellite gateway might also be used to allow local packet operators to access the satellite directly

The PACSAT forwarding system is likely to host the first routine use of the 4800 baud PACSAT capabilities.

Work on this part of the ground segment (and the space segment) is just now getting under way.

Gateways — Analog

Gateways for allowing local FM repeater based access to analog satellites, particularly AMSAT-OSCAR-10 and AMSAT-OSCAR-13, have been seen in various locations sporadically for several years. As with the digital gateways just discussed, their limited success is largely attributable to a lack of consistent week after week, month after month availability of the gateways to interested local users. In general, long before users can do any more than experiment with the satellites remotely, i.e. before regular schedules are moved to satellite via gateway or any routine use is made of them, or they can be trusted for emergency or traffic communications, the gateway operator loses interest in manning the system day in and day out and it effectively disappears.

As with digital gateways, hardware and software automation (and, of course, appropriate operating authorizations) can go a long way toward alleviating this sociological problem. Equipment is now within our reach, or nearly so, which will make possible satellite gateways that require as little tending (and monitoring) as a PBBS or a repeater. A standard, working approach to the problem is needed.

From this, satellite access advancements can grow. Frequencies can be coordinated and user-end command capabilities added to allow users to "dial" or select one gateway from another or to select gateways from normal satellite operation or to select satellite frequencies from a gateway. The quantum leap in popular usability of satellites via such gateways will probably not come until several dozen such repeater linked systems are in place, in continuous operation, in the Phase-4 era. Now, however, during Phase-3, is the time to start developing the technologies and techniques.

Various proposals have been made at various times, but no unified effort is now under way on any large scale. This situation must be changed soon as we approach Phase-4.

Special Interest Groups

At the present, AMSAT is just beginning to organize specific subsets of its user support in a way utilized by other similar organizations, through "special interest groups" (sometimes known as SIGS). The reason for this slight formalization of what already basically exists (in some cases) is to stimulate more growth, interest, activity, and information than is currently seen in any of these areas.

Most people reading this paper are probably AMSAT veterans enough to know that our domestic authority on Mode S is Bill McCaa, KØRZ, that one of the foremost leaders in weather satellite work is Jeff Wallach, N5ITU, and that the pre-eminent AMSAT-OSCAR-13 DXers in North America are led by John Fail, KL7GRF/6. Information like this is not, however, widely known to newcomers or presented regularly in AMSAT publications except by inference.

Special interest group coordinators will receive correspondence, (paper, electronic, and real time as appropriate) about the subject of interest, maintain an AMSAT mailing sub-list of interested operators, and try to keep them regularly polled about and informed of relevant activities

and late news.

Every subject discussed in this paper is a prime candidate to become the focus of an AMSAT special interest group.

Satellite Product Development

Many ideas have surfaced recently for relatively specialized products to make some facet of satellite operation more straightforward or even automatic, and possibly less expensive.

Antenna AutoTracker

At the 1989 annual meeting of Project OSCAR in Los Altos, Ca in January, I spoke with Technical Director, Jeffrey Pawlan, WA6KBL, about supporting their development and distribution of a low cost, fully generic antenna rotator controller. The basic design of the AutoTracker consists of a simple microprocessor connecting to a computer on one end via a serial (RS-232) port and connections to all control lines of most popular rotators on the other. The "black box" basically solves all hardware problems of getting from any computer (with a serial port) to any rotator set. Computer software will send pointing commands and read results from the box in the same way regardless of what rotators are used. This makes the software interface simpler to specify and relatively portable. Configurations are selected by some combination of dip switches, cabling, and initialization commands. Other tracking systems available now are either computer or rotator specific or both thereby limiting their marketability and universality.

CSDP recruit Bruce Rahn, WB9ANQ, working with WA6KBL, has brought this project up to the prototype stage at the present time. I hope to see introduction of a kit version of this "universal rotator interface" soon at a price of under $100.

DOVE Receivers

Project DOVE leader Dr. Junior DeCastro, PY2BJO, has arranged for 1000 special DOVE receivers to be constructed for use in schools everywhere. This single act will do as much or more than any other one action initiated by AMSAT recently to promote Amateur Radio and Amateur satellites to a new group of enthusiastic people. More important, it brings the space age and the promise of science and engineering into classrooms some of which would not otherwise have had such an opportunity.

Satellite Novices

One complaint we hear a lot is that satellite operation is very expensive and relatively complex. I believe that this incorrect perception results from several outdated perceptions of Amateur Radio in general. One is that the average Amateur starts out on hf and builds some sort of reasonable hf capability before moving into "exotic" modes like ATV or satellites. Developed in that way, the total cost of an Amateur station can indeed be high. It is our view that Amateurs can and should be recruited specifically for satellite work. What does hf have that satellites do not? DX? Nets? Rag chews? QRM? Repeater quality contacts under favorable conditions?

Another misconception is that the price of Amateur Radio gear is higher than ever before. Compared to inflation, Amateur Radio equipment prices have actually declined or at least held steady for the last 30 years. Today, a middle of the road but full featured, state of the art hf rig is in the $2000 range. Was the same status possible in 1960 for $100-$150?

Another problem encountered is the notion that a vhf-uhf station should be set up like an hf station, with radios inside on a desk, antennas outside in a good, high location, and coax running in between. At 70 cm this approach begins to have problems and at L band and above, it is simply the wrong technique, particularly in view of cost effectiveness.

In order to address these and other concerns, some of us in AMSAT management have been exploring the idea of developing what amounts to a "satellite novice rig." Mode L is tentatively selected for several reasons and an "HT range" price tag is the goal. Mode L is picked because: 1) we now have a satellite with significant Mode L time, 2) Mode L is the transition band from Phase-3 to Phase-4 (which will have Mode L but will major in "true Mode S," 23 cm up and 13 cm down), 3) Mode L needs to be promoted both for AMSAT-OSCAR-13 and for frequency utilization purposes, and 4) it is quite probable that we can obtain authorization for an extension of the 23 cm USA Novice band to allow for satellite operation (the current allocation is 1270-1274 MHz, 5 Watts maximum).

Also, most arguments made for inclusion of two meters on Amateur satellites (such as AMSAT-OSCAR-13 Mode J) center on cost and availability of appropriate equipment in third world countries and other impoverished areas (like most of the U. S., apparently). The proposed equipment would be as inexpensive as two meter gear both here and abroad and it or something like it could be made available most any place. Local regulations for 23 cm transmissions will still be a problem in some countries.

Basically, the proposed system consists of a direct oscillator/multiplier/amplifier transmitter chain, a good preamp, and a

simple, possibly even a direct conversion, receiver. All are mounted at an antenna in simple, weatherproof enclosures and powered and controlled over lines which carry only DC or baseband signals. This replaces expensive coax or hard-line with something cheap like 6 or 8 conductor rotator cable. A simple control head in the shack has audio, switching, any frequency control, and possibly DC connections. The antenna needs to be steerable but this can be done manually at first to keep costs down. Many articles about very inexpensive L band and other satellite antennas have been published recently, as in the May 1989 *73 Magazine*, for example.

Of course, there are many upgrade routes for such equipment, but the initial priority is to keep the entry level cost and complexity down.

(By the way, contrary to the Amateur popular press, preamps are not ''optional'' ''accessories'' for Amateur satellite rigs. Nearly anything will work for a receiver, direct conversion, converters to hf, or all mode radios, given enough signal to noise ratio at the input. Adequate signal to noise ratio can only be set by a good preamp/antenna system.)

Phased Array Antennas

Perhaps the most fascinating idea for an innovative and revolutionary Amateur satellite product is the steerable phased array. At uhf and above, this no-moving-parts, high-gain beam has many advantages (and some drawbacks) compared with the traditional dual-rotator-with-many-yagis-on-booms or steerable dish setups.

The principle is fairly simple. Build up a two dimensional array of dipole or equivalent antennas with quarter wave spacing. At 70 cm, a 10 X 10 array (of 100 antennas) would be about five feet square, roughly the size of a nominal backyard dish. Each antenna has a solid state three bit (nominal) phase shifter, allowing eight possible phase values (-180, -135, -90, -45, 0, 45, 90, 135 degrees). Multiplex the 300 control wires to a computer port and the rest is ''only software.'' For a given desired beam direction, calculate the relative phases for each element, round to the nearest allowed value, and set up the phase shifters.

Advantages are that with no moving parts there are no blatant mechanical problems like coax hanging in nearby trees, or rotator grease freezing up in the winter. Such a unit could be constructed in an rf transparent enclosure to look very similar to a solar water heater. Most communities that object to outside antennas and towers do not (by consensus) object to solar water heaters. Transmit and receive arrays need not be physically close together. Steering from one part of the sky to another is instantaneous and there is no ''due south wrap around'' problem.

Disadvantages include the fact that the ''plumbing'' required to feed rf to all of the elements will get complicated and expensive unless some creative innovation (the AMSAT watchwords) is employed in the design. Also, switch-like steering introduces phase discontinuities in the signal which probably will not be objectionable on voice but may disrupt PSK or other data transmissions, particularly at higher data rates. Gain is not constant in all steered directions as it (approximately) is with beams and dishes. Gain falls off toward the edge of the field of view. Sidelobe patterns are different and vary with steering. The basic unit, a single element with its phase shifter, must be made very simply and inexpensively so that 100 (or 25 or 400) can be constructed within reasonable cost limits.

Disadvantages notwithstanding, the potential for apartment, portable, mobile, and other limited space residents may be worth the tradeoffs, and, after all, AMSAT engineers tend to be a clever bunch and can probably overcome some if not all of the problems.

As with all of the other projects discussed in this paper, at least one volunteer is needed to physically analyze this problem, build up a prototype, and quantify the associated costs and problems.

DSP

No discussion of Amateur satellite related products is complete anymore without at least a mention of DSP. As has been reported fully elsewhere, the same people who are the DSP project leaders have been building MicroSats for the last two years and most progress has been on hold for that period of time. DSP is still the way to process baseband (modems, filters, dynamically adaptive systems, etc.) for the Amateur Radio of the future.

I expect that in the next few year, production of DSP and related software will replace the creation and porting of satellite tracking programs as an entry point for AMSAT engineering talent. Indeed, the current leaders of the DSP effort, Tom Clark, W3IWI, and Bob McGwier, N4HY do not intend to produce fully finished, user ready software, but only to work out the thorniest of the internal coding problems and to provide direction and assistance with the remainder of the production tasks. This leaves room for substantial contributions from a potentially large number of programmers for some time to come. Keep one thing in mind though: This sort of work has traditionally been done on a volunteer basis.

Don't put 100 hours into a program then decide that you need to be compensated for it somehow. Decide up front. If you are going to donate the product to the cause, great. If you are going to market, do your market research right, set up distribution channels, contact AMSAT before assuming anything about the size or ease of availability of the AMSAT market. Based on what you learn, you may just want to donate your effort or not do it at all rather than go through all the fuss just to be disappointed. And remember, hundreds of AMSAT volunteers donate countless hours of time doing other things, building hardware, elmering, promoting AMSAT at hamfests, giving talks at meetings, and so on without any reimbursement. There is no good reason why programmers should be any different from all the other supporters.

MicroSat Receiver

The group led by Tom Clark, W3IWI, that developed the MicroSat receiver has indicated that a version of the receiver might be produced for ground based digital work. As the unit is designed for high reliability, automatic operation, low power consumption, compact size, and design simplicity, it is a likely candidate to play a role in station automation required for gateway operations.

Interface to Other Organizations

In recent months, two relatively serious groups have approached AMSAT-NA about using MicroSat or small satellite like technology on demonstration or scientific space missions. The first is the World Space Foundation based in South Pasadena, California. Their project is the Solar Sail.

The World Space Foundation resembles early AMSAT in several ways. A group of workers in aerospace (government and industry), somewhat frustrated with the inability of big bureaucracies to develop highly promising, slightly risky technologies, forms a group and on an unpaid, after-hours basis does the job that is needed partly from fascination with the project and partly from a desire to be in the middle of the action.

Over the past several years, volunteers at the World Space Foundation built a machine to make solar sails, determined a sail deploying method, then designed and prototyped a solar sail vehicle.

Since this project is dealt with in another paper in this Symposium, it won't be discussed further here except to note that the World Space Foundation has approached AMSAT-NA for help with ''Avionics,'' (transmitters, receivers, computers, and other flight electronics), frequency allocations, and tracking.

Another group working out of the

University of Huntsville has approached AMSAT for essentially the same sort of support for a Lunar Polar Prospector mission.

Orbital Data Management

Two years ago, I was assigned to the AMSAT-NA position of Orbital Data Manager. After I developed a rudimentary reformatting, checking, and distribution system, Ralph Wallio, WØRPK, undertook the task of receiving element sets from NASA and preparing weekly electronic releases and information for publication as required.

This system and its philosophy need more work, preferably to be done by one or two people for whom this is their major volunteer contribution to AMSAT. Electronic mail capability and programming experience are required. Another Orbital Data Manager will be appointed when a suitable volunteer emerges.

MicroSat Dynamic Model Study

As far back as OSCAR-7 and 8, some AMSAT satellites have been stabilized by a passive magnetic, photon torque method. The four MicroSats are also stabilized in this way. Essentially, magnets are mounted along an axis of the satellite (the Z axis for MicroSats) which then track the magnetic field lines of the Earth producing a two rotation per orbit rotation of that axis (for polar orbits). Turnstile antenna blades are then painted in such a way that sunlight exerts a torque about the Z axis causing the spacecraft to rotate several times per minute. The process is regulated by lossy damping rods mounted perpendicular to the torque axis.

In connection with MicroSats, a study has been initiated to attempt to model this dynamic behavior and to provide a method for quantifying and verifying the model using satellite telemetry and other physical data. Each satellite has monitored sensor values which can be analyzed to extract dynamic behavior information. Further, the WEBERSAT has a camera which, if successful, can provide high resolution verification data (on the order of sub degrees of arc).

Two individuals, Dan Schultz, N8FGV and Gerry Creager, N5JXS and two groups, Weber State College (under Bob Twiggs at the Center for Aerospace Technology) and the U. S. Air Force Academy (coordinated by Major Wiley Larson), have received information and are proceeding with analysis or related assignments. Results of both the modeling and verification process will be reported in the future.

Connections to Other Hobbies

For some time, I have been interested in the prospect of extending Amateur satellite and Amateur Radio influence into other avocations. As an example, one area in which there is potential for enhanced visibility and mutual benefit is in the area of Amateur astronomy. Already, an Amateur astronomy club in Orange County, California which has a remote telescope and viewing site is supported at times by a local ATV repeater group. A beam splitter is used on the telescope to simultaneously attach an eyepiece for local viewing and TV camera for Amateur transmission of images.

The possibilities are limited only by the willingness of Amateurs in both hobbies to cooperate and share in the excitement. Many astronomical events (such as eclipses or occultations) occur over broad geographic regions. Hams can easily support real time voice and data communication between remote observing sites and can even provide networks for data collection and reporting. A recent issue of *Sky & Telescope* discussed the need for a network of many Amateur sized telescopes in various locations to provide continuous data on variable stars. As long as the project remains one in which professionals are not directly involved in the process, automatic data collection from all the sites is an ideal application for a PACSAT type network with its full time, whole Earth coverage.

In another connection, AMSAT has recently held discussions with Steve Roberts, N4RVE, author of *Computing Across America* and developer and pilot of the high tech, recumbent bicycles, Winnebiko I and II. His current project, Winnebiko III, intended for international nomadic wanderings will be equipped with a complete AMSAT-OSCAR-13 portable station and continuously operation PACSAT gear. The goal is to have "telemetry" and messages available from Winnebiko III via PACSAT on an regular, automated basis.

Steve's involvement in Amateur Radio and the satellites exposes all sorts of new folks who might not otherwise have the opportunity to our hobby and our particularly interesting corner of it. This includes bikers, campers, hikers, most outdoors types, computer hobbyists (who are interested in Steve's multicomputer, multitasking, fully networked system), and just basically everyone who he encounters along the road. Also, his visibility as the "high tech nomad" in the media is turned into positive PR for Amateur Radio at every opportunity.

Summary

In this paper, I have presented an overview of most of the projects and activities that come under the auspices of AMSAT Operations at this time except for Field Operations which is well established and is very ably headed by AMSAT-NA Vice President for Field Operations, Jack Crabtree, AAØP. Clearly, I need a lot of help to carry out any of these tasks, much less all of them.

My intention in promoting so many different ideas and programs is to provide a structure for meaningful contributions from a large number of Amateurs throughout the organization regardless of their location or other circumstances. There are projects that are technically simple and others that are more challenging. There are some that are expensive and some which require no cash outlay. Some require coordination with or coordination of, a group of like-minded workers, others can be done in solitude. Some (like net participation and rag chewing) are not technical at all, beyond the expertise and equipment that is needed to operate satellites in the first place. AMSAT builds satellites in a distributed engineering effort, technical contributions come from all over North America and all over the world. These same techniques can and will be applied to ground-based projects as well, enhanced by the Amateur Radio communications facilities AMSAT is providing, satellites like AMSAT-OSCAR-13 and the PACSATs.

AMSAT-NA is a special and unique organization in that, without significant institutional support, members have taken orbiting satellite projects from conception to on-orbit operation successfully time after time. This institutional personality has been idolized by the members for many years. Every one of you has doubtless had the same dream that I have had, of ultimately being able to work on an actual satellite construction program in some capacity. After thinking long and carefully about AMSAT Operations in the context of an aggressive and expansive Amateur Radio of the future, I have decided that ground-based projects, that make full and optimum use of the satellites and visibly promote what we have to offer, are just as important as actually working on the satellites themselves.

It has been and will continue to be my view that important contributions are made by those who use satellites and who improve the performance and reach of the Radio Amateur Satellite Service. Whatever your skills, temperament, and resources, there is something important for you to do. Come join me and let's get moving!

Small Expendable-Tether Deployer System Student Experiment Package SEDS SEP

By

Edward F. Stluka, W4QAU, and

Charles C. Rupp, W4HIY

Abstract

The Small Expendable-Tether Deployer System (SEDS) will be flown as a secondary payload to a United States Air Force Global Positioning System (GPS) satellite primary payload now scheduled for launch in the middle of 1991.[1] The SEDS will be attached to the exterior electronics bay wall on the second stage of a Delta II 7925 launch vehicle. The Student Experiment Package (SEP), a 50 pound payload will be deployed from the SEDS on a 20 kilometer tether. The SEP will contain student experiments, a control and data system and an Amateur Radio system using a Motorola Amateur Radio Club furnished 4 Watt transmitter. The Marshall Space Flight Center Amateur Radio Club (MARC) is integrating the SEP.

This paper describes the SEP flight operations planning and the required Amateur Radio support for acquiring and recording the flight data. The need for the AMSAT and American Radio Relay League (ARRL) participation is discussed. The student experiments, the SEDS and the SEP mission profile are summarized.

Background

The SEDS flight objective is to demonstrate that the 20 km tether can be fully deployed without stopping prematurely, that it can come to a smooth stop on application of a brake, and can cut the tether at the proper time after it swings to the nadir. The SEDS will store and down-link data to be used to determine the performance of the tether assemblies and the accuracy of the tether dynamics models. The SEDS was originally planned to deploy a 50 pound dead weight end mass on the 20 km tether. Chris Rupp, W4HIY, the Treasurer of the MARC and the lead engineer on SEDS asked Ed Stluka, W4QAU to consider putting a payload of experiments in the end mass instead of using a passive weight. This resulted in a proposal for a tether payload of student experiments, data, power and control systems and an Amateur Radio beacon for down-linking the flight data.

Approach

Chris agreed to design and build the data and control system. Correspondence with AMSAT, Vernon (Rip) Riportella, WA2LQQ (past AMSAT President) and Doug Loughmiller, KO5I, AMSAT President, resulted in the approval of the use of the 435.430 MHz AMSAT-OSCAR-13 compatible frequency for the transmitter. Harold Sanderson, WB4TTA of the Fort Lauderdale, FL Motorola Amateur Radio Club provided the transmitter. Amateur Radio Operators (ARO) and Short Wave Listeners (SWL) are needed to record the digital data to be transmitted to ground stations. AMSAT and ARRL coordination is of great importance in disseminating the SEDS-SEP mission information to the ARO ground stations and providing updates of launch and SEDS/SEP information.

Small Expendable-Tether Deployer System (SEDS)

SEDS is managed by the Marshall Space Flight Center in Huntsville, AL. The Energy Science Laboratories, Inc., (ESL), San Diego, CA is the mechanical systems contractor. The University of Alabama, Huntsville is the electronics system contractor. Subcontractors to ESL are McDonnell Douglas for Delta II interface studies; Teledyne Brown Engineering for engineering analysis and documentation; and the University of California in San Diego for fabrication of the SEDS and the SEP structures.

Figure 1 shows the location of SEDS on

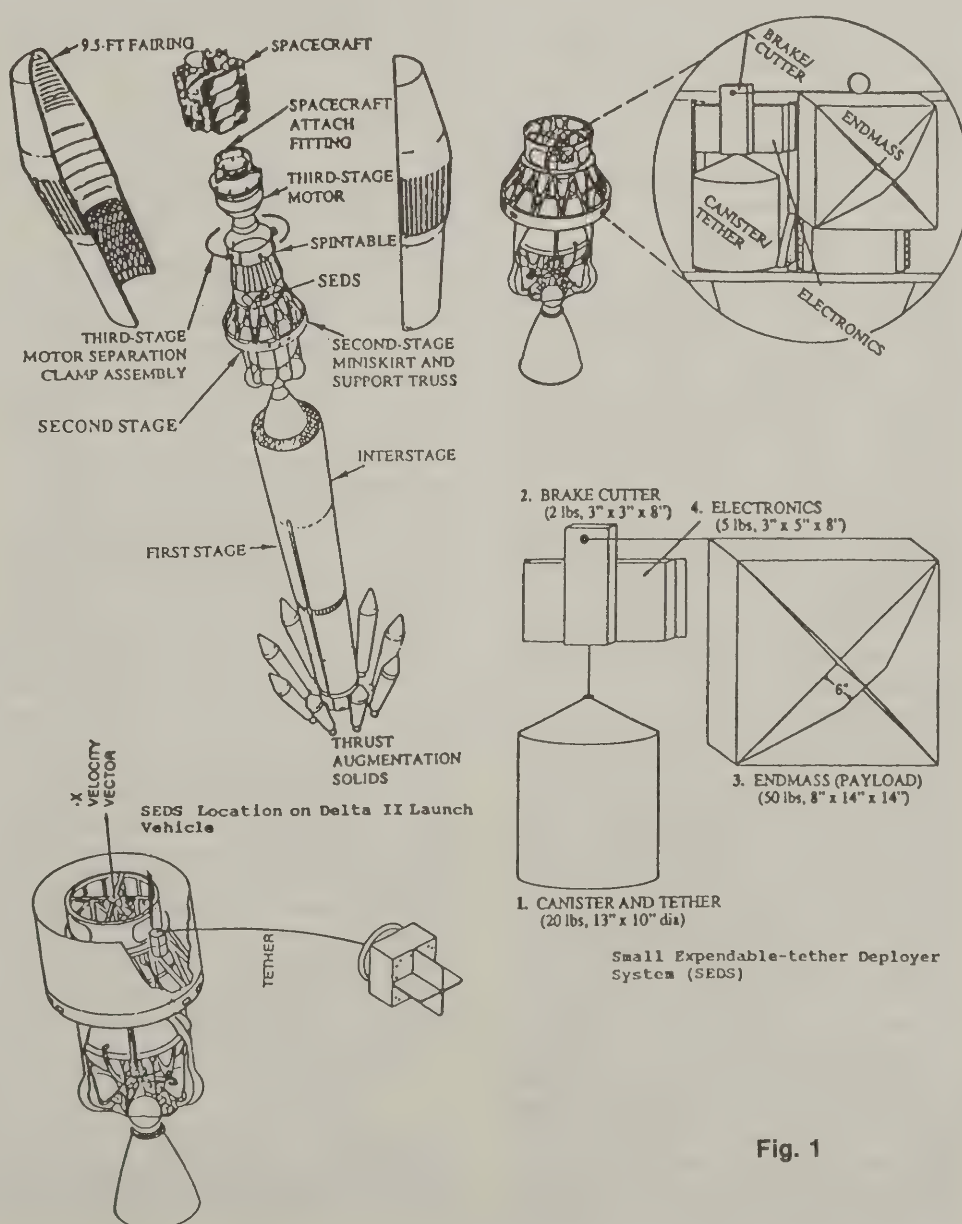

Fig. 1

the Delta II Launch Vehicle, the SEP deployment from the Delta II second stage and the major assemblies of the SEDS and SEP.

SMALL EXPENDABLE - TETHER DEPLOYER SYSTEM

STUDENT EXPERIMENT PACKAGE SYSTEM

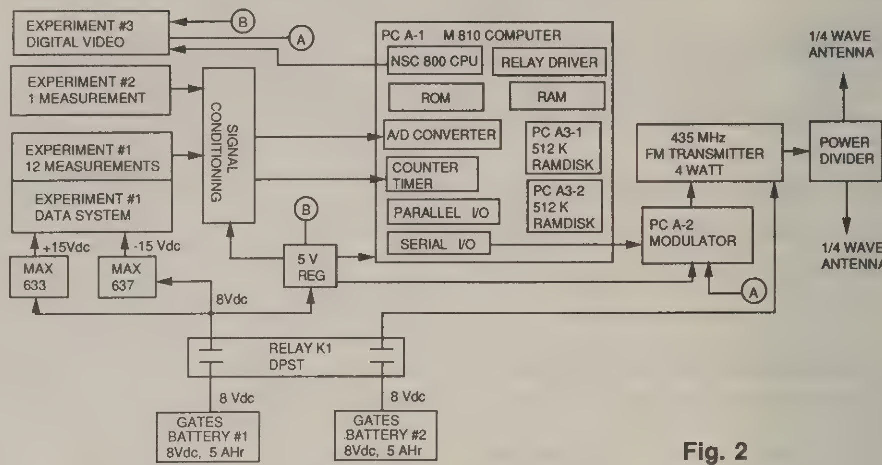

Fig. 2

Mission Operations Concept

SEDS, will be activated by a sequencer command from the Delta II telemetry system after the GPS primary payload has been deployed. The sequencer command starts a 1.5 hour SEDS 20 km tether deployment, initiated by spring ejection of the SEP at a speed of 1.5 M/S. The deployment will start at the apogee of a 110 X 380 n mile orbit, and last for 5800 seconds (1.6 hours) or a little more than one SEDS orbit. During deployment the tether position is about 50 degrees above the vertical. The polyethylene synthetic fiber tether (SPECTRA-1000) unwinds from a stationary aluminum core, feeds through a friction brake assembly, a cutter, and is finally attached to the payload. A stepper-motor, operated by the electronics system, applies the brake that controls the tether tension during payout and thus the tether deployment speed. Full deployment is reached at 5100 seconds followed by a 50 degree swing downward to the nadir that is completed at 5800 seconds, when the tether is cut. This angle minimizes the sensitivity of the final trajectory to modest tension errors during deployment.

After deployment is completed, the tether swings to a near-nadir position where it is cut at the deployer end and allowed to reenter the Earth's atmosphere about one-third of an orbit later. The SEP operations will end when the payload is destroyed by the re-entry environment.

Measurements to be made are a count of the turns as the tether unwinds to give tether length and speed, tether tension and deployer temperature. The SEP has retroreflectors that enable radar tracking from the ground.

The SEDS electronics data and control system will record, store, and continuously down-link over the Delta II S-band telemetry channel data to the ground. It will count the turns as the tether unwinds from the core, control the tether brake, and activate the cutter that severs the tether. It serves as an event timer and responds to sequencer commands from the Delta II second stage. Data stored, besides the turn counts, are tension, temperature, and supply Voltage. The storage capacity is 160 kilobytes (approximately 115 kilobytes are required) and the down-link capacity ranges from 1 kps to 64 kps. Expected requirements are from 1 kbps to 5 kbps.

Only a few rotations of the brake are needed near the end of the tether deployment to slow the payout speed and bring the tether to a smooth stop. The stepper-motor operates the brake. About 1.5 hours after the experiment begins, the cutter, activated by an explosive charge, severs the tether ending the SEDS tether control of the SEP.

Student Experiment Package

The student experiments currently are: Experiment #1, a 3 axis servo accelerometer, by Robert Newberry, a University of Alabama-Huntsville student. The objective of Experiment #1 will be to obtain acceleration data in three levels. Four signals per axis, for a total of 12 outputs will provide the three levels of acceleration (10-1, 10-2 and 10-3 G) and one temperature measurement from each transducer. A dedicated data system processes the data for output to the SEP data system. Exp. #1 requires +15 Vdc and -15 Vdc with 250 mA and weighs 1.26 pounds.

Experiment #2 is a Free Electron Laser Wiggler (FELW), developed by Mike Muckerheide, Director of the Genesis Laser Laboratory, Milwaukee, Wisconsin and students at the Milwaukee School of Engineering. The FELW requires no power, contains neodymium doped iron magnets and weighs 10 pounds. One measurement, from a silicon wafer sensor, will provide FELW performance data. The objective of the FELW is to prove that a laser can operate without external power by free electrons from space plasma.

Experiment #3 is in a very preliminary stage and is expected to be additional three-axis accelerometer sensors with lower g level capabilities than Experiment #1.

SEP Data System Description

The computer system uses a low power, high performance single board computer designed for control processing and data logging applications. The capabilities designed into the system include the following:

Serial I/O	1 channel, 50 to 9600 baud, user programmable
Analog Input	32 channels, 0-5 V or 1.25-3.75 volts, with scaling resistor patch space.
Discrete I/O	Two 8 bit programmable parallel ports plus one 5 but port, of which 16 bits can be high level relay drivers.
CPU	National NSC800 which runs Zilog Z-80 instructions at a clock speed of 2 MHz.
Memory	EPROM: up to 32K bytes, CMOS RAM: 32K bytes, CMOS RAM Disk: 1 M bytes.
Power	8 to 35 VDC at 55 Ma., -5 to -12 VDC at 5 to 12 Ma for operational serial interface;3 VDC at <10 ua for operational RAM battery backup
Size	5.25 x 10.25 x 3.25 inches overall.
Weight	5 pounds.
Temperature	Military grade, -55 to +125° C.
Connectors	MS3470 Series.
Software	Furnished with M810 Monitor and M810 Tiny Basic.

The software is capable of executing user software upon power-up using either machine code or Tiny Basic user programs. The baud rate is initialized at power-up to 9600 baud, but user programs can change the rate.

Figure 2 is a block diagram of the SEP System. The regulated power supply is integral with the computer chassis assembly. Four circuit cards are integrated into the chassis as follows:

A1 Board - M810 CPU, ROM, RAM, I/O, timers, analog inputs
A2 Board - Analog signal conditioning, telemetry monitor
A3-1 Board - Mass memory, 512 K bytes
A3-1 Board - Mass memory, 512 K bytes

Transmitter Modulator

The amount of data generated by accelerometers can be quite large, depending on the sample rate. The present scheme is to store all the data in the RAMDISK and continuously downlink the data stored. Even at 9600 baud, the downlink of the total memory (1 Megabytes) requires about

20 minutes. NASA will use a faster rate when over a government tracking station, to allow all data to be collected in a single pass. 9600 baud appears to be the rate to which Amateur satellite stations are migrating. The G3RUH modulator[2] appears to be the choice for use by the SEP telemetry.

SEP Ground Station Requirements

The PACSATS offer an excellent opportunity for practicing reception of SEP data. Stations capable of receiving the 9600 baud PACSAT data should prove adequate for the SEP data. The ground station data buffer should be 512 K to store data acquired in an 8 minute pass. Government ground stations will store telemetry ''video'' data on tape for demodulation at a later time.

SEP Data Format

A 261 byte telemetry frame has been chosen for the binary data. The first two bytes will be two sync characters, FFH, followed by two binary bytes indicating the frame count. The 256 bytes of binary data are next and the end of the frame is a single check sum byte. Because the data is repeated, this simple scheme should suffice, if redundant data is received by several ground stations.

SEP Power

The SEP power will be supplied by Gates Energy Products Cyclon Batteries. Two 8 Volts, 5.0 Ah 1x4 DS Shrink Wrap #0800-0104 batteries, 3.33 pounds per battery will be used. The SEP power usage:

LOAD	Amp	Hours	Amp Hours
Exp. #1	0.94	2	1.88
Transmitter	1.6	2	3.2
Data System	0.04	2	0.08
TOTAL	2.58		5.16

The SEP power available is 10 Ah, with the experiments known at this time.

SEP Mass Properties

The present mass properties shows 31 pounds of the 50 pounds available.

Much planning is required to finalize the SEP.

SEP Flight Operations Planning

ARO and SWL ground stations require a good knowledge of the SEP Ground Track in preparation to acquire and record the data. The current Orbital Trace for SEDS operations and for SEP deployment is shown in Figure 3. The SEP power and the Amateur Radio beacon is activated at SEP deployment, which begins near Hawaii, at approximately 170 degrees west longitude and is completed 85 minutes later at about 130 degrees east longitude. The swing takes about 10 minutes, so the tether will be cut over the Pacific Ocean at about 150 degrees east longitude. The SEP reentry takes one-third of an orbit so the tether and the SEP should reenter over the Pacific Ocean near 100 degrees west longitude.

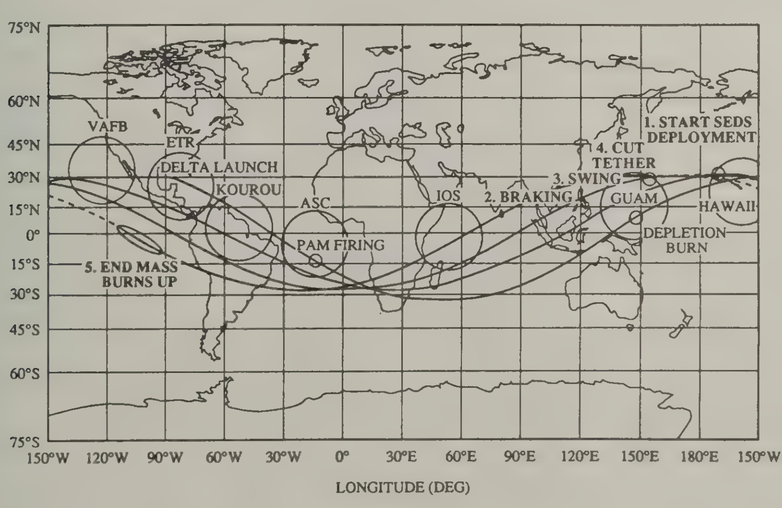

Fig. 3

Possible Orbital Trace for SEDS on a Delta II 7925/GPS Mission with Depletion Burn and Descending Node Injection

AMSAT and ARRL Support

The support from AMSAT and ARRL during the GAS #007, Project Explorer (student experiment package)and the Marshall Amateur Radio Club Experiment (MARCE) was paramount in the extremely successful STS-61C, Columbia flight, January 12-18, 1986. The same type support is needed for the SEDS-SEP mission, now scheduled for mid 1991.

References

[1] *AIAA/NASA/ASI/ESA Proceedings*, CP892, Tether in Space, Hyatt Regency, San Fancisco, CA, May 12, 1989

[2] 9600 Baud Packet Radio Modem Design, James Miller BSc, G3RUH, ARRL Amateur Radio 7th Computer Networking Conference, Columbia, Maryland, October 1, 1988

WEBERSAT

By
Stan Sjol, WØKP
Asst. Vice President, Engineering

One of the four MicroSats soon to be launched contains Amateur and educational experiments designed and built by students, faculty and volunteers at Weber State College. Weber State and its Center for Aerospace Technology (CAST), located at Ogden, Utah, built the NUSAT-1 satellite which was successfully launched from a getaway special canister on the Space Shuttle in 1985.

The WEBERSAT spacecraft is physically larger than the other MicroSats. In addition to the transmitter, receiver, battery and CPU modules, which are the same as the other MicroSats, WEBERSAT has an extra three inch module which houses the unique experiments on this spacecraft. The dimensions of WEBERSAT are nine inches by nine inches by twelve inches, not counting the various antennas extending from the surfaces.

The experiments in the WEBERSAT module include a color CCD camera, a high speed flash digitizer, an "L" band television receiver, a particle impact detector, an Earth horizon detector, a visual light spectrometer and a flux gate magnetometer.

The color CCD camera is a repackaged Canon with auto iris and lens that has a resolution of 700 pixels by 400 lines. The camera's output is either NTSC standard video with color burst or separate red, green, and blue signals with horizontal and vertical synchronization. The camera has an iris that is computer controllable with automatic override to stop down the lens in direct sunlight. The CCD target sensitivity is computer adjustable. The camera has a light range that can look at the Sun on the bright extreme and at starlight on the dim extreme.

A high speed flash digitizer board utilizing an eight bit digital to analog converter captures the video from the CCD camera and stores the digitized image in RAM memory. The board is software agile allowing the sample rate, data array size, analog data channel, data phase, and trigger source to be controlled by the computer. The flash digitizer is DMA interfaced to the banked memory system allowing multiple pictures to be stored and compressed for downloading as data files.

A 1265 MHz "L" band receiver will allow direct uploading of NTSC standard AM video. The output of the receiver is composite video, which can be routed to the flash digitizer under computer control and a single frame digitized. This digitized image can also be stored in memory as a data file and downloaded on command.

The particle impact detector has a small, sensitive piezoelectric crystal which is mounted on the outside surface of the Weber module. The monitor can detect small impacts on the surface and record the number and magnitude of collisions. The experiment was designed and built by the students and faculty of Brighton High School in Salt Lake City Utah.

The Earth horizon sensor consists of two sensitive photocells mounted on either side of the camera lens and set eleven degrees apart. They will be used to determine when the camera is pointed Earthward. They can also be used to measure the speed of rotation of the spacecraft.

The visual light spectrometer is a linear array camera with a 5000 pixel target. Light is focused through a slit onto a 0.1 to 2 micron diffraction grating. The resulting diffracted light spectra falls onto the linear CCD array where the spectrum of light is digitized. The resulting data gives the light frequency spectrum as the positional intensity of the array. The light spectrum received can indicate the composition and molecular structure of the gases at the Earth's surface that reflected the light. The spectrometer will give an indication of the presence of harmful gases in the upper atmosphere or the absence of gases like ozone.

The flux gate magnetometer can map the magnitude and direction of the Earth's magnetic field during the course of the satellite's polar orbit. This two axis unit can also be used to measure the spacecraft's rotation and tumble speeds.

In addition to these experiments the WEBERSAT also has full capability of functioning as a backup packet radio PACSAT.

Solar Sail Program Status

By
John Garvey, N6VHP, and
Dr. John Champa, K8OCL

As discussed in "Sailing to the Moon," *AMSAT Journal*, Volume 12 Number 2, August, 1989, AMSAT-NA is supporting the World Space Foundation (a nonprofit space research organization in southern California) in its efforts to develop a solar sail spacecraft that would participate in a race to the moon. This event — the Columbus 500 Space Sail Cup — is being organized jointly by the American Institute of Aeronautics and Astronautics and the Quincentenary Jubilee Commission. It is scheduled to take place in late 1992 and is intended to commemorate both the International Space Year and the 500th anniversary of Columbus' discovery of America. The World Space Foundation team is bidding to provide the entry for the Americas, which would compete against spacecraft from Europe and Asia.

Project definition has advanced significantly during the past several months. In the avionics area, the current thinking is that redundant, full Mode S operation (1.2 GHz up, 2.4 GHz down) will be necessary for communication at lunar distances. Also, an additional transmitter in the C-band portion of the spectrum (5.8 GHz) would provide a backup to the S-band downlink. Although this will restrict the number of ground stations that are initially capable of working the Solar Sail Race Vehicle (SSRV), the savings in antenna size and mass for both the spacecraft and ground facilities justifies this selection. Additionally, the development work on Mode S and Mode C systems for the Phase-4 geosynchronous satellites will be directly applicable for the SSRV. Finally, the widespread availability of television-receive-only (TVRO) ground stations for commercial communications satellite signals should facilitate the C-band operations (because current COMSATs broadcast TV signals at C-band frequencies, it is possible that adapting the associated receiving equipment to SSRV operation may just require some retuning).

If space, mass and power margins permit, a 2 meter and/or Ka-band beacon may also be included in the rf system. As discussed below, the first capability would support educational programs while the SSRV is still near Earth. The second option would lead to a major improvement in spacecraft tracking accuracies. Discussions on this subject are currently under way with NASA's Jet Propulsion Laboratory (JPL), which is developing this Ka-band technology for its planetary exploration program (such discussions are helped by the fact that several World Space Foundation officers are also JPL employees). In return for providing an early flight demonstration opportunity, the Foundation team would receive support

both in the form of hardware and access to NASA's Deep Space Network.

For command and control, the present concept is derived from the MicroSat computer module, which is based on a NEC 400 chip. The primary issue is what kind of orbit the SSRV will start from, which in turn will determine the radiation environment that the computer must tolerate. If it is a geosynchronous transfer orbit, the spacecraft will spend a significant amount of time in the Van Allen belts, while a higher orbit (i.e. geosynchronous) would result in a more benign situation. If the race organizers do select the former case, additional work may be required to either assure that the MicroSat computer can operate successfully, or else change to a more radiation-tolerant system like that on AMSAT-OSCAR-13.

Because of the greater degree of mechanical actuators on the SSRV compared to previous OSCARs, as well as extended ranges of operation, the SSRV will probably require a new power system that will have to be designed over the next year.

Specifically, the spar and sail sheet deployment motors will consume a great deal of power during the initial sail operations, while pyrotechnic separation devices will require short bursts of high current. Later, during regular operations, power will be needed for the actuators that will drive the attitude control vanes and a mast that will support a television camera which may be supplied by Weber State College. Consequently, it appears that the SSRV will have a larger contingent of solar arrays and batteries than the Amateur satellites that have been launched to date.

The solar sail project team has also been exploring several programmatic endeavors that would complement the SSRV effort. In particular, a "SAILTRAK" education program, based on the experiences gained from SKITREK and, hopefully, Project DOVE would provide information concerning the SSRV's location and status to the public. While the SSRV is near Earth, a 2 meter beacon with a voice digitizer on the spacecraft could utilize the same ground infrastructure that is currently being developed for the MicroSats. Alternatively, other Amateur satellites, packet radio, and the ANS bulletin board could relay such data.

A key participant in undertaking SAILTRAK would be the Planetary Society, which is the largest nonprofit space organization in the country. Through the Society's unique ties with the educational community, it should be possible to engage a new segment of the population in the sail race, and Amateur Radio satellite operations in general.

These issues are among the many currently being addressed by the World Space Foundation team. In addition to AMSAT-NA and the Planetary Society, other team members include universities (Utah State) and aerospace corporations (McDonnell Douglas). Together, this team will resolve these issues and then generate a final design during the first phase of the solar sail race program, which will end in the fall of next year. If the SSRV is selected to represent the Americas, vehicle development will begin shortly afterwards, with launch scheduled for late 1992. Given this aggressive schedule, perhaps it's not to early to start discussing whether operating a remote transponder in lunar orbit qualifies as a new DX location.

For further information on the Solar Sail Project, contact the World Space Foundation at (818) 357-2878.

The Lunar Polar Prospector

A Giant Leap in Cooperative Space Efforts

By
Dennis Wingo and
Dr. John Champa, K8OCL

The Lunar Polar Prospector (LPP) project is a cooperative effort of space advocacy and lunar science groups to conduct meaningful space science in the form of a spacecraft placed into lunar polar orbit. This mission will be part of the public's effort to support the International Space Year's (ISY) theme of "exploration, discovery, scientific inquiry and global cooperation." outlined by NASA administrator Richard Truly and President Bush in July of this year at the National Academy of Sciences conference on the ISY[1]. The Lunar prospector mission is a mission that has been on the drawing boards of NASA since the end of the Apollo Lunar Missions. The Jet Propulsion Laboratory (JPL) completed an advanced design study for the Lunar Observer spacecraft as early as 1977[2]. This mission has been continually delayed by Congress and currently is not slated to be a new start by NASA until 1992[3]. In 1985 SSI commissioned JPL to do a design study based on the concept of a Lunar Getaway Special Mission launched from a Shuttle Getaway Special payload canister. This mission would have been ion powered and would have taken two years to complete the trip to the moon[3]. This mission fell in the wake of the Challenger disaster and the issue of the long stay in the radiation belt of the science instruments.

So far no one besides the World Space Foundation's (WSF) solar sail project is slated to be launched to the Moon in the foreseeable future.

The Lunar Prospector effort is being funded by the Space Studies Institute (SSI) of Princeton N.J. The University of Alabama in Huntsville (UAH) is answering the Request for Proposal (RFP) sent out by SSI in June 1989[4]. The due date for the proposal was October 1989. The RFP was the result of two conferences and years of effort sponsored by SSI and the Houston Space Society, (a flagship chapter of the National Space Society). At the first conference in March 1989 SSI formed the Lunar Prospector Team to coordinate the Prospector effort. AMSAT had representatives at this conference to talk about the spacecraft communications issues. At the second conference the science instruments and spacecraft configuration was chosen for the RFP.

Mission Objectives

The primary objective of the prospector mission is to complete the mapping of the distribution of certain elements present in the lunar surface regolith. This mission is a continuation of the Gamma Ray Mapping missions of Apollo 15 and 16. The scientific mission is a necessary precursor to any large scale unmanned or manned mission to the Moon. A second objective of this mission is to enable the cooperation of groups in the space advocacy and Amateur Radio community and to show that we have the resources and determination to complete an ambitious scientific mission. In addition it is also felt that the time is now for this type of mission because of the president's recent speech outlining the goal of NASA to return to the Moon. Furthermore, UAH in its proposal is including onboard the spacecraft two transponders that would do double duty as scientific and engineering telemetry transponders and Amateur Radio user transponders. Another factor in this mission is the challenge associated with controlling a spacecraft leaving from Earth orbit, traveling to the Moon, completing the required burns to enter the proper orbit and receiving the telemetry; all of these tasks will be carried out by Amateur Radio! This mission will truly be in the highest tradition of Amateur engineering and science begun by Hiram Percy Maxim.

Science Background

During the post-Apollo 11 lunar missions opportunities arose to do mapping of elemental abundances in the equatorial regions of the Moon. The Apollo spacecraft was limited to an orbital inclination of no more than 16 degrees due to fuel limitations and landing support operations.

Apollo 15 and 16 carried out a program of gamma ray spectrometry using a sodium iodide detector interfaced to the main Apollo CSM communications system. This program enabled lunar scientists to map approximately 16% of the lunar surface for the abundances of titanium, iron, thorium, potassium, and uranium. This information helps lunar scientists understand the composition and evolution of the lunar crust. Since iron and titanium are economically important metals, mapping their distributions over the lunar surface will aid in determining the economic potential of the Moon.

Excellent maps of the distributions of these elements have been compiled by the U.S. Geological Survey and the planetary data centers in Arizona and Hawaii. Dr. Ray Hawke, director of the planetary data center at the Hawaii Institute of Geophysics in Honolulu, Hawaii has compiled maps of the distribution of ilmenite. Ilmenite is the mineral from which titanium is refined. In some areas the titanium concentration is as high as 16%. With the days of dwindling mineral resources of Earth upon us, it is felt by a growing number of organizations around the world that we must begin to use the resources of the entire solar system. If we do not, the alternative is the prospect of a much poorer world for ourselves and our children.

Science Instruments

The primary science instrument of the LPP spacecraft is the Gamma Ray Spectrometer. At this time it is planned to use a spare detector left over from the Apollo program. The instrument uses a detector made of sodium iodide with a plastic sheath to capture the gamma rays. This instrument will be used by the lunar prospector to complete the elemental survey by using a lunar polar orbit to enable complete coverage of the lunar surface. In addition the Apollo instrument will be modified to run in a neutron mode which

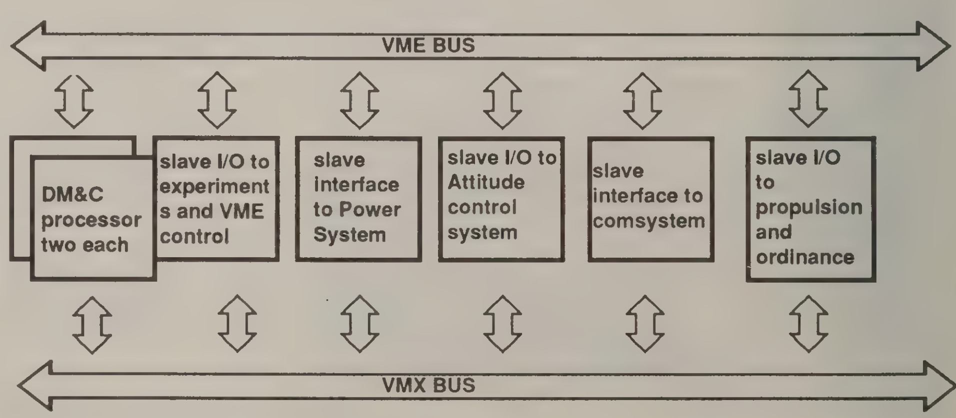

Fig. 1

will allow the detection of water ice in the permanently shadowed regions of the lunar poles.

Theoretical calculations show that at temperatures below −190 degrees centigrade such as are thought to exist in these shadowed regions, water ice would be stable over the life of the solar system. Such a discovery would have a profound effect on the future course of the exploration and colonization of the Moon. Finding water on the Moon is the equivalent of having found a gas station in the sky where you could "fill'er up" and get a glass of water for free.

The second major science instrument is the Alpha Particle Reflectometer. This instrument will map the distribution of radon release sites and determine the frequency of radon release events. Radon is a radioactive gas released in the lunar environment by volcanic activity. While radon is not important itself economically, the release of radon gas is always accompanied by other gases such as nitrogen and sulfur dioxide. These gases would be of value to the life support system of a lunar base. In addition the gas release sites would be a source of thermal energy that would also help to reduce the requirements for supplies in the lunar transportation system.

The third science instrument is the Magnetometer and Electron Reflectometer. These instruments are donated by the Houston Space Society. The instruments will be used in tandem to map the magnetic fields of the Moon. Although the Moon does not have a global magnetic field like the Earth, it does have weak fields of a local extent. Mapping the strengths and distributions of these local fields over the lunar globe will determine if they were caused by an earlier global magnetic field like the Earth's or if they have some other origin. In addition to these scientific goals, the magnetic experiments will be used to determine the temperature and iron content of the lunar mantle and will help to find out if the Moon has a small metallic core.

The fourth and final experiment is the Doppler Gravity experiment. This experiment will use the AMSAT supplied Mode S, (1.2 GHz uplink 2.4 GHz downlink) transponder. Also included will be a hybrid Mode C, (1.2 GHz up 5.8 GHz down) transponder. Both transponders will be used for Doppler ranging to map the Moon's inconsistent gravitational fields and for operational backup. Despite the earlier Apollo, Lunar Orbiter and Russian missions to the Moon, we do not have an accurate enough map of the lunar gravity field to allow orbital predictions to be made with the degree of certainty needed for future manned mission operations. This is because none of these earlier missions were in low polar orbits. Lunar Prospector will provide this needed operational data set on the lunar gravity field. It will also provide scientific data on the density differences in the crust, the nature of the mass concentrations (mascons) in the lunar "Seas", the internal density of the Moon and the existence of a small metallic lunar core.

The Doppler experiment is the most challenging from the standpoint of ground operations and coordination of the worldwide gathering of scientific and engineering data. This will also be the first demonstration of real-time telemetry monitoring and display for advanced low cost personal computers. The Lunar Prospector team, working with AMSAT will be pushing the state of the art in both coordination, operation and design for the AMSAT and general Amateur Radio community. This experiment will foster the development of the AMSAT Deep Space Network (ADSN) to support the solar sail project and a wide variety of other interplanetary missions operated by Amateurs!

Spacecraft Design

At this point in time the spacecraft design is in the preliminary stage. Also it is to be understood that this is a proposed design. The design presented here is a mixture of the requirements laid out by the SSI RFP and the design baseline under development by the UAH.

The basic design of the spacecraft called for in the RFP is for a spin stabilized spacecraft. This requirement places constraints on both the type of science instruments used and the antenna design for communications. The spin rate of the satellite is set at between 3 and 30 rpm. The spinning mode was chosen because of its relative simplicity and it best supported the science packages on board the spacecraft. The magnetometers require a spinning satellite to be able to gauge the variations in the extremely weak lunar magnetic fields. It is also not possible to use the magnetic torquing method used for the AMSAT spacecraft because of the absence of a robust magnetic field such as exists for the Earth.

Another basic design limitation placed on the spacecraft is that the dry weight must not exceed 205 kilograms. This limitation is so that the lunar prospector can qualify for the Arianne minisat program with a wet weight of 600 kilograms. This limitation will require the extreme use of weight management techniques to allow for a capable spacecraft within these limitation. A major issue at this point is whether it is feasible to use composites for major structural members such as the frame or the internal equipment mountings. The only vehicle using composites at this time are the Pegasus vehicle made by Hercules and Orbital Sciences Corporation (OSC).

Discussions are taking place with OSC to determine if we can incorporate this technology on the spacecraft. Weber State College (WSC) will be in charge of the structural design and fabrication of the engineering development unit spacecraft and all internal plumbing and wiring.

Another limitation on the spacecraft is the telemetry data rate. To be able to build a low weight spinning spacecraft it became necessary to exclude any experiments with high data rates. This meant that no imaging experiments could be included on the bird. The maximum data rate on the satellite downlink for the science and engineering telemetry is approximately 9600 bps.

In the area of propulsion a very important issue at this point is the lack of a launch vehicle. The RFP asks that three different mission scenarios be provided for, these are: lunar insertion from geosyncronous transfer orbit (GTO), lunar insertion from low Earth low inclination orbit (LEO), and low Earth polar orbit (PLEO). This ambiguity places an extreme burden on the propulsion designer

The communications subsystem will be supplied by AMSAT. The transponders mentioned above will allocate four telemetry channels to the onboard science and engineering telemetry. The Mode S and Mode C operation will have the benefit of having compact antennas with relatively high gain and a good radiation pattern. The Amateur Radio transponders will occupy a to-be-determined frequency spectrum above the frequencies allocated for the spacecraft telemetry. Communications with the AMSAT transponders will require a small-to-medium size dish using a reasonably high quality low noise amplifier front end for the ground receiver. The path loss is several orders of magnitude less than with traditional EME modes. The spacecraft can be tracked after insertion into lunar orbit by using the standard tracking software provided by AMSAT.

The data processing system onboard the satellite may have to be of a more sophisticated design than is currently used by AMSAT or most other spacecraft. It is proposed that the IEEE 1014 bus or "VME bus" be utilized for its reliability and support for multiprocessing at a low cost[5]. Multiple processors and memories will be used to lower the cost and allow for redundancy in design not feasible with a "start from scratch" approach. Figure 1 is an example of the architecture proposed for the data management and command subsystems and their interface to the rest of the spacecraft. An alternative to this design would be to use the AMSAT MicroSat command and data system. This depends on the amount of flight software intelligence required by the attitude con-

trol system. Either of these designs could be used to support both AMSAT Phase-4 and the WSF solar sail program. In fact one of the main benefits to all parties concerned with low cost efforts such as the ones noted here is the large amount of commonality in the spacecraft design. This commonality will certainly lower the costs of all of our spacecraft projects.

Conclusion

It should be clear now that designing a Lunar satellite is no trivial operation. This spacecraft will tax to the limit the distributed engineering techniques pioneered by AMSAT and other organizations such as SSI. Our UAH team feels that with AMSAT support in the area of communications and their advisory role in other areas of the spacecraft design, coupled with the structures building experience of WSC and the computer engineering design and simulation capability of UAH in proximity to a major NASA engineering center, that a successful spacecraft can be built. Perhaps if the ARRL declares lunar orbit as a new country, avid DX'ers would even be willing to help fund the project.

In closing it should be clear that with dedicated effort of people and organizations from around the country and the world that a major contribution can be made to science and Amateur Radio education by this cooperative effort. The inclusion of this mission in the planning for the ISY in 1992 will give this and the WSF solar sail effort the visibility and support on the national and international scale that can show that the people involved in Amateur Radio and space advocacy are willing to work for a more positive future.

Acknowledgments

We wish to thank AMSAT's Vice President of Operations, Courtney Duncan, N5BF, for the help with reality checks of our communications approach. Also thanks to Robert Twiggs at WSC and all of the people that we have spoken to at AMSAT for being more than helpful in answering our questions and providing information and support both for our proposal and for this paper.

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[2] Jet Propulsion Laboratory, Pasadena CA, Lunar Observer Design Study 1977.

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[5] Dennis Wingo, "Using the VME bus as a low-cost spacecraft data bus", *I.E.E.E. Proceedings 1989*, Southeastcon, April 10, 11, 1989, University of South Carolina, Columbia, SC.

UoSAT/MicroSat Launch Rescheduled for 19th January 1990

By Jeff Ward, GØ/K8KA

Firm information on the new UoSAT/MicroSat launch date has been received from Arianespace. The rescheduled launch of SPOT-2, MicroSats A through D and UoSAT-D and UoSAT-E will take place on 19th January, 1990. The launch campaign will start roughly 30th November, with the UoSATs and MicroSats being integrated to the ASAP (Ariane Structure for Auxiliary Payloads) on or about 14th December.

Dear Joe...

(Letters to the Editor)

Quiktrak

One parameter that's very confusing is in QUIKTRAK's use and display of MODE at the top of the map screen. The manual devotes one short paragraph to it, and from reading the *ARRL Experimenter's Handbook*, I'm able to deduce that satellites have times in which they are available for different modes, but how do I program the QUIKTRAK program? Where does this information exist? What do I program in for AMSAT-OSCAR-13, let's say, and does it change every third week or whatever? — *Hal Mandel, KA1XO*

(Anyone familiar with the program who can help out. Hal is in New Hampshire and can be reached at (603) 224-9673. — Joe)

Telemetry

Dear Joe: Allow me to call your bluff. I teach in an average high school. I have an excellent satellite ground station. My computer does not do very well on 45 baud. I would love to have my advanced physics students copy AMSAT-OSCAR-13 telemetry as a regular part of their course but our Kantronics software won't do the job.

If the job can be done on an IBM, Apple 2+ or Commodore computer with the proper software and a Kantronics interface, please fill me in on the details. — *Dave Reeves, Chaminade College Prep., WA6BYE - Club Station, 7600 Chaminade Ave., West Hills, CA, USA 91304*

(Try 50 baud for a start. I hope to have an article on the subject in a forthcoming issue of the Journal. *— Joe)*

Orbital Elements

Dear Joe: In the Aug. issue, HB9AQZ and NH6N seem to be unsuccessful in their quest for orbital elements. All their problems can be solved for the price of a stamp.

NASA provides a free service that will put anyone on a mail list for elements of up to 20 orbital bodies. You may request these by object name and number (if known), or simply ask that you would like the elements for the Ham Satellites, or the Weather Satellites, or the Navigation Satellites, or whatever group you may be interested in.

Write to NASA Goddard Space Flight Center, Code #513, Greenbelt, Maryland 20771.

These elements will be mailed to your doorstep and be updated every 7 to 10 days. No more hunting up BBS systems that may have the information, or relying on someone else to get them for you. Not bad for a quarter... — *Steven Roberts, N7BLA*

QSL Cards

Dear Joe: Today there are many challenging and desirable Satellite Awards, all of which require QSL cards for the proof that the two way communication took place, and this is the problem.

Lately I've seen lists from very rare and exciting stations together with the recommended procedures to obtain a QSL card. Sad to say, it seems that the common practice of "via the bureau" is bypassed more and more these days and a variety of green stamp and IRC guidelines prevail.

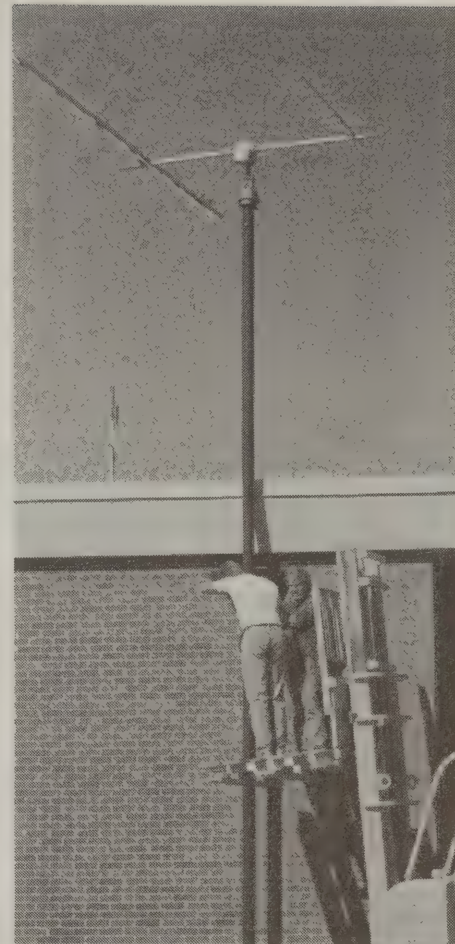
There are no binding QSL rules in Amateur Radio and I also fully accept a decision by an Amateur *not* to QSL. It is after all his free choice, but I would appreciate if the following reminders were to be published.

1. Whether or not a station likes to exchange QSL cards should clearly be indicated in the QSO and if "special" QSL procedures apply, please state so.

2. QSL Managers are of great help, however, both parties involved should be in full agreement as to what procedure applies. (There have been instances where

(Continued on page 37)

Space Technology Education Through the Combined Efforts of Industry, Education, and Government



By

Dr. William G. Clapp

Realistic engineering training at the college and university level is a difficult task to accomplish successfully. There is no substitute for the on-the-job training that takes place after graduation. Many colleges and universities offer senior projects courses that are designed to help the student transition into their entry-level engineering position.

Weber State College has been attempting to create one of the best senior projects courses in the country. The largest factor in our recent successes has been our satellite projects that have involved local engineers, faculty, and students. Recent joint projects with AMSAT-NA have provided tremendous opportunities for our students and faculty. A satellite is an ideal project because it is a well-defined complete system. It does not take up valuable storage space during construction and long term storage problems are eliminated when it is put into orbit.

The Weber State College Campus is located 40 miles north of Salt Lake City, Utah. Our campus is nestled up against the Wasatch Mountains with an overlook of the Great Salt Lake. We are midway between the University of Utah and Utah State University.

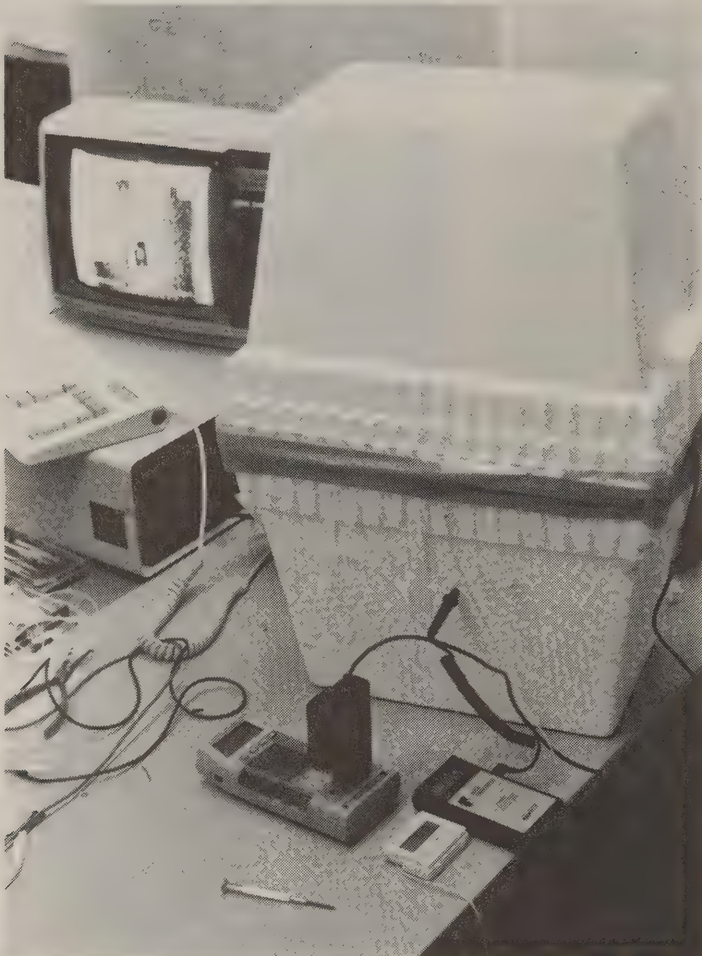
Weber State College has passed the 13,000 student mark and 1,000 of these students are enrolled in the School of Technology. The three major departments within the School of Technology are (1) Electronics, (2) Manufacturing, and (3) Mechanical. Within the School of Technology is a department called the Center for Aerospace Technology (CAST) which was started and is currently being directed by Robert (Bob) Twiggs. Bob was the catalyst behind our first satellite, NUSAT-1. CAST coordinates the projects that cross departmental lines.

The four-year Bachelors of Science Degree in these three areas require that each student complete a one-year, three quarter, six credit, senior projects class. Each senior project student contributes 300 hours of service completing the senior projects requirements in a team environment solving realistic engineering problems. This is not just a paperwork exercise, but the projects must be designed, built, debugged and demonstrated to the faculty a number of times during the year. Team size depends on the complexity of the project. Team sizes have varied from three students to sixteen. The largest team, sixteen students, was needed in building the Phase-4 Model during the 1988-89 school year. For this one project alone, students donated nearly 5,000 hours of free labor. Satellite projects at our college have consumed about 10,000 student hours annually.

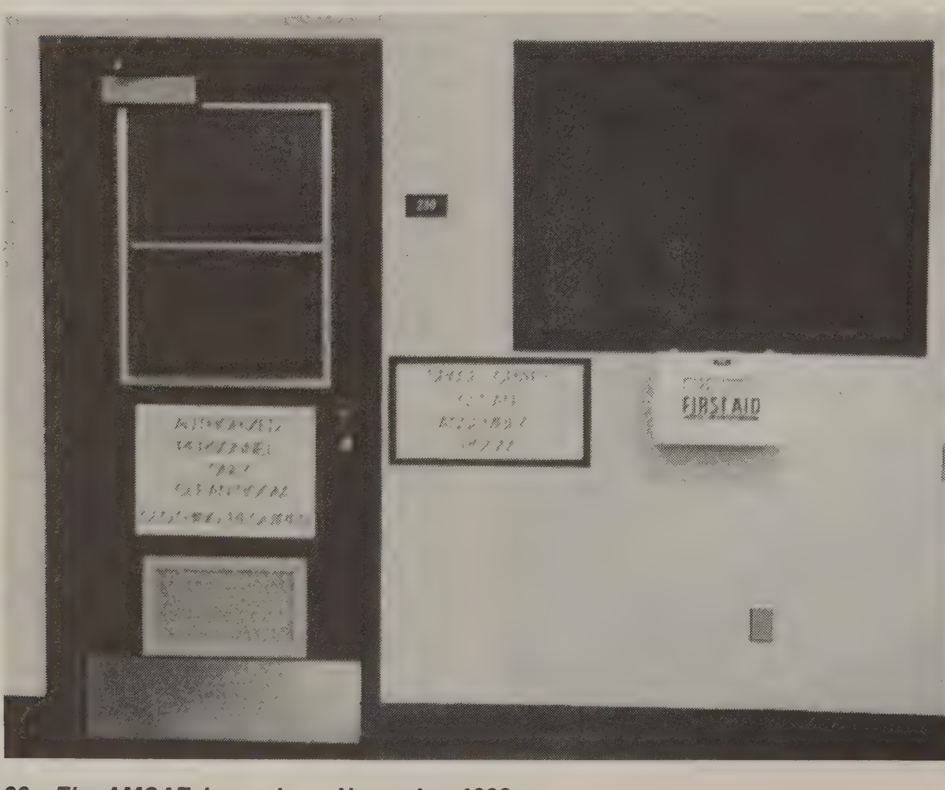
Engineering advisors are recruited to provide technical assistance to the teams. These advisors have been volunteers who thrive on helping young engineering students learn their trade. Our advisors have averaged about 1,000 hours of free consulting work per year in support of the satellite projects. Of course, engineering advisors are difficult to come by and are treated as kings. The engineering advisors for the AMSAT projects have been licensed Amateur Radio operators holding either the advanced or extra class ticket.

Many projects have been completed with astounding success. We occasionally have had failures for a number of different reasons. Clearly defining the problem for the students has reduced the failure rate considerably. The satellite projects over the last few years have provided opportunities that we thought were impossible to achieve.

NUSAT-1 was launched into orbit aboard the Shuttle Challenger in April 1985. NUSAT-1 was designed and built by a group of volunteer engineers, faculty, and students from Weber State College and Utah State University. The cash outlay for NUSAT-1 was less than $20,000. Over 1500 two-way communications were com-



Above left: WEBERSAT Module being thoroughly tested at the simulated space temperature. Above right: Recently completed Weber State College ground station. Below: Weber State College clean room.



pleted through NUSAT-1 during its 20-month life before it burned up over the Indian Ocean. Its mission to calibrate FAA radars throughout the world was not totally realized because of the unanticipated density of the radar signals.

NUSAT-2 was being developed while NUSAT-1 was still in orbit. The second satellite would have enhanced capabilities to complete the FAA experiments. The structure was qualified as space ready and the electronic systems were prototyped before the shuttle disaster occurred. Work on NUSAT-2 was discontinued soon after because of the lack of low cost launch opportunities.

Weber State College joined the AMSAT team to build four similar satellites currently scheduled to be launched by an Ariane in November 1989. Weber State College manufacturing students have built many of the mechanical parts for all four of the MicroSats.

One of the four MicroSat satellites has been designated as WEBERSAT and will carry an additional module that will house a CCD color camera, light spectrometer, microwave receiver, and a high school designed and built impact sensor. The WEBERSAT Satellite design and construction began in April 1988. WEBERSAT weighs in at less than 25 pounds, five pounds more than the MicroSats, and is

Phase-4 Model being readied for display at the June ARRL National Convention in Arlington, Texas.

Weber State College students assembling Phase-4 Model.

many times more capable than either NUSAT-1 or 2. All of the circuits in the Weber State College module were designed and built by volunteer engineers, students, and faculty at Weber State College.

The Phase-4 Satellite is yet another satellite that Weber State College has teamed with AMSAT to help design and construct. This satellite will weigh one thousand pounds and will go to a geostationary orbit. The main mission will be to downlink educational video from the US Space Station to classrooms throughout the country. Weber State College students have completed the full-scale model and will continue further design and construction during the upcoming year.

Weber State College has again been funded for some additional work on the Phase-4 project. The antennas, electronic packaging, and composite struts have yet to be incorporated into the model. AMSAT funding only covers the cost of materials. The next major step, yet unfunded, will be the fabrication of a Phase-4 Satellite that can endure the structural testing. The structural model would require significant funding that has not yet been made available. AMSAT has been attempting to find donors or customers willing to help fund the project.

Weber State College desires to continue in the satellite design and manufacturing business for years to come. Some of the CAST team would like to have a satellite in orbit around the moon within ten years. The team of over 100 volunteer engineers, students, and faculty have contributed over 15,000 hours per year over the last five years. The students are graduating with realistic engineering experiences and high recommendations from their volunteer engineering advisors. The excitement and thrill of launching our own satellites has made all the effort worthwhile.

Dear Joe...

Continued from page 34

the QSL Manager mentioned in a QSO was not aware of his appointment).

3. QSL cards can be a delight but they don't need to be a work of art. Simple low cost cards are adequate.

4. Some states in the USA are as hard to work as a rare country (i.e. RI and DE). A QSL card from such a state is more valuable than one from a commonly workable state such as W6.

5. That the ethics of QSLing in general be improved.

73s — *Hanspeter Nafzger, HB9AQZ*

Crash Landings (Oops)

Dear Joe: You made a tiny mistake in printing my article ''Getting On Frequency on AMSAT-OSCAR-13 with Precision and Without Causing QRM'' in the last issue of the *Journal*. The example of the use of the Doppler formula was wrong. You printed

Doppler Frequency = 1398 - 975.1 - 424.2 or 1.3

You should have printed the 1.3 with a ''minus'' sign in front of it, namely,

Doppler Frequency = 1398 - 975.1 - 424.2 or -1.3.

I hope you will publish a correction, otherwise many will follow your incorrect example and will have completely unsatisfactory results.

Thank you for a very nice publication.
73 — *Maury, K4GMJ*

Dear Joe: I find it incomprehensible that AMSAT is still listing the Mode S beacon frequency as 2400.325 MHz when the Beacon frequency is in the vicinity of 2400.650 MHz. This misinformation was last repeated in the last issue of the *AMSAT Journal*. I have yet to locate any AMSAT or ARRL literature correcting this error. I realize that there are currently less that 40 of us active on Mode S and since becoming active I have talked with several uhf and microwave enthusiasts who converted their 2304 gear and attempted to locate the Mode S beacon. When they were unsuccessful due to the wrong frequency being published, they abandoned the try.

I have sent a number of operators who have expressed an interest in Mode S the following information, which now that

Mode S is functioning so well, deserves publication in the *Journal*.

1. If you can operate Mode B successfully, you have enough uplink power for Mode S.

2. The Mode S beacon is in the vicinity of 2400.670 MHz not on 2400.325 MHz as published.

3. The recent early September 1989 fix of the passband has produced good news and bad news. The good news is that the signals are considerably improved (by 3 or 4 S units in my receiver). If you were discouraged by attempts before the fix, give it a try now and you will be pleasantly surprised. The bad news is that Mode B signals can be heard in the passband. The Mode B stations have no way of knowing when they tune up on a Mode S QSO. The portion of the Mode B passband that is echoed on Mode S is the downlink between approximately 145.885-145.920 MHz, generated by uplinks between approximately 435.510-435.575 MHz. This unfortunately seems to be the section of the Mode B passband used most heavily.

4. The Mode B signals which are present in the Mode S passband are by convention LSB. Mode S on the other hand will be USB. I have made a practice of identifying my CW transmissions as being on Mode S. A number of cross mode contacts have been made by transmitting USB between 435.10 MHz and 435.575 MHz which can be copied by stations receiving both Modes B and S.

5. The Mode S beacon and transponder are not on at the same time, as on other modes.

6. Mode S is not an inverting transponder. Your USB signal comes back as USB. If you move higher in frequency, your downlink will also move higher, like on the RS birds. 73 — *Tom, K8TL*

Advertisements

SAREX Notes Number 2

By Ron Parise, WA4SIR

Here are a set of prelaunch predicts for STS-35 and all of the possible operating windows for SAREX based on the current launch time and crew cycles. The elements might change slightly prior to launch due to some new ascent performance predictions but not by much. These should do fine for any planning exercises about the mission. These are preliminary and are NOT yet official. Our launch time is now April 26, 1990 at 05:02 GMT.

The first column of the operating windows for SAREX lists the opening and closing of the window in Mission Elapsed Time (MET) and is essentially independent of launch time. The second column is the corresponding GMT assuming an on-time launch. Note that if the launch slips, the MET windows will stay constant but the corresponding GMT's will slip to more or less favorable times depending on your geographic position.

These windows are for crew tended operation only and do not include the much longer periods in which robot packet operation will be available. Also be aware that not all of the listed windows will have SAREX operation scheduled in them. These are only the possible windows.

If you use the orbital elements given above, you will find that the US has very few passes which occur within these windows. This is unfortunate but is the luck of the draw for mid-deck payloads. On the other hand Japan, South America, Australia, and South Africa will have good coverage. There is the possibility that other windows may open due to gaps in the primary payload timeline or the willingness of other crew members to operate SAREX but we cannot assume anything at this time.

Satellite:	STS-35
Epoch time:	90116.2618056
Element set:	JSC-004
Inclination:	28.4867 deg.
RA of node:	120.8747 deg.
Eccentricity:	.0012355
Arg of perigee:	10.1548 deg.
Mean anomaly:	355.7859 deg.
Mean motion:	15.71276482 rev/day
Decay rate:	2.8E-04 rev/day^2
Epoch rev:	02
Semi Major Axis:	6736.21 Km

```
Potential Operating Windows for SAREX
 Based on 26-Apr-90 05:02 UTC Launch

         Window Open - Close Rev
   MET                         UTC
 (dd/hh:mm)             (at window open)
                       (dd-mmm-yy hh:mm)
-------------------------------------------

00/10:30 - 00/11:00  26-Apr-90 15:32 - 16:02 08
00/19:00 - 00/22:00  27-Apr-90 00:02 - 03:02 13
01/10:15 - 01/12:00  27-Apr-90 15:17 - 17:02 23
01/20:00 - 01/21:15  28-Apr-90 01:02 - 02:17 30
02/08:45 - 02/10:30  28-Apr-90 13:47 - 15:32 38
02/18:30 - 02/20:00  28-Apr-90 23:32 - 01:02 44
03/07:45 - 03/09:30  29-Apr-90 12:47 - 14:32 53
03/17:30 - 03/19:00  29-Apr-90 22:32 - 00:02 59
04/06:45 - 04/08:30  30-Apr-90 11:47 - 13:32 68
04/16:30 - 04/18:00  30-Apr-90 21:32 - 23:02 75
05/05:45 - 05/08:00  01-May-90 10:47 - 13:02 83
05/16:00 - 05/17:30  01-May-90 21:02 - 22:32 90
06/05:45 - 06/08:00  02-May-90 10:47 - 13:02 99
06/16:00 - 06/17:30  02-May-90 21:02 - 22:32 106
07/05:30 - 07/07:00  03-May-90 10:32 - 12:02 115
07/15:00 - 07/16:30  03-May-90 20:02 - 21:32 121
08/04:15 - 08/05:45  04-May-90 09:17 - 10:47 130
09/05:15 - 09/05:45  05-May-90 10:17 - 10:47 146
09/11:45 - 09/13:45  05-May-90 16:47 - 18:47 150
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Off the Pad

Continued from page 1

An AMSAT Space Symposium is not just a get together of the ''in crowd'', patting themselves on the back. It is a chance for anyone to put their ideas before the attendees and to get together with the hard core and exchange ideas. For new ideas to evolve into something practical, they usually need some help. There are only 24 hours in a day, and most of the hard core are volunteers with full time jobs in the ''real world'' who are busy doing their AMSAT activity in their spare time. As a result, new ideas have a time (i.e. we don't have the time to deal with them right now) barrier to cross. It's not that the hard core are not interested in those ideas, they are just busy. Right now what with Phase-4, the MicroSats and Digital Signal Processing they are real busy. The symposium is an excellent place to discuss your new ideas in real time with the hard core, get their opinions, and find other involved people and set up a working group to explore those ideas further.

Symposium attendance usually works out to around 150 to 200 people. This is unfortunate for a number of reasons. The proceedings get a very limited circulation and the information contained in it is not disseminated very far. In order to get a somewhat larger distribution of the material, the ARRL has reprinted the proceedings as an ARRL publication. Even so, the total number of people who have had access to the information contained within the proceedings has been relatively small. You must have noticed the advertisements for them. You probably never considered ordering a copy of the Proceedings thinking that it was too technical.

This year we are starting something new. This issue of the *Journal* is the Proceedings of the 1989 AMSAT Space Symposium. This alone ensures a wide dissemination of the information it contains. As you read it, you will get an inkling of what is going on behind the scenes. You will see how plans for the future are shaping up. You will see new projects proposed. You will see that not only is the road to Phase-4 being traveled, but goals are being set up to put Amateur Radio on the Moon (or close enough to it). If you are interested in what happened in previous years, contact Martha at the office, she may just have some copies of those symposium proceeding left that she will be glad to supply to you.

If you were not at this symposium, then you missed the chance to explore some of the new ideas, you missed the chance to get the background behind each of the papers, you missed the chance to see the slides not included in this volume, and you missed the chance to talk to the presenters

individually. Why not seriously think about attending next year's AMSAT Space Symposium?

President's Forward

Continued from page 1

the attendees of all of these meetings.

For the past couple of years the ARRL has published our proceedings for us and provided them to interested Amateurs as an ARRL publication providing a somewhat larger distribution of the material which has been presented at our annual meeting. However, the total number of people who have had access to the information contained within the proceedings has been relatively small. This has been an unfortunate occurrence in my opinion. The technical accomplishments of AMSAT volunteers rank among the most significant advances within the Amateur Radio hobby today. Very few of our members have a true appreciation of the details which comprise these accomplishments and Radio Amateurs in general possess an even narrower view of this vista. This is a situation which I have a keen desire to see change. It is my hope that both our members and Radio Amateurs in general can have better access to information about the many exciting projects which AMSAT is currently supporting.

Recently AMSAT Executive Vice President John Champa, K8OCL, and I were discussing this situation and through the course of this discussion the idea came forward to publish this year's proceedings as an edition of the *AMSAT Journal*. Following consultations with *Journal* editor Joe Kasser, G3ZCZ/W3, it was decided to do so. It is our feeling that all AMSAT members will benefit from access to the Symposium papers. While not as comprehensive a view as sitting in on the presentation of the individual papers, one can garner an appreciation for the current state of the Amateur satellite program.

We sincerely hope that you enjoy this special edition of the *AMSAT Journal*. Our thanks to all of the authors who contributed material, to Joe Kasser, G3ZCZ, and Bob Myers, W1XT, who worked very diligently against a very tight timeframe to insure availability in time for the Des Moines Symposium and to Ralph Wallio, WØRPK, and the Central Iowa Technical Society volunteers who collected material from authors and who have worked very hard to make the 1989 AMSAT Annual Meeting and Space Symposium a great success.

73 and see you in Des Moines!

Doug Loughmiller, KO5I,
President and General Manager

Fund Raiser Rocket!

The first $30,000 of this Fund Raising Campaign will be used to complete the current MicroSat projects. The remaining $50,000 is to be used to complete the Phase-IV Geostationary Satellite design. Please be sure to help with your donation this year: send contributions to AMSAT, P. O. Box 27, Washington, DC 20044.

Individuals and organizations who wish to contribute to a specific AMSAT-NA project are welcomed to earmark their donation. Of course, technology and other resources developed for one project are often used to facilitate the development of a future project, e.g. much of what is being learned in the development of the MicroSats is being used to assist in the development of the Phase-IV Geostationary Satellites, i.e., our projects are interdependent. Just as a great deal of information gained in the construction of previous OSCARs was used to develop the MicroSats, in turn a great deal of the information obtained in MicroSat development will be used to improve the Phase-IV Satellites. Therefore, regardless of your interest in packet radio, your support of the existing MicroSat Project is very important to the development of future OSCARs of all types.

Special appreciation and recognition goes out to the following contributors for their generous and consistent support:

• Central States VHF Society, at their 1989 Annual Meeting, had Dr. Tom Clark, W3IWI, AMSAT-NA President Emeritus and Director, as the banquet speaker. Tom's presentation was titled ''A Retrospective Look at the Future: The Past and Future of American Technology and Amateur Radio''. At the conclusion of Tom's presentation The Society presented a $400 donation to AMSAT-NA!

• Six Meter Club of Chicago, K9ONA, has donated $250!

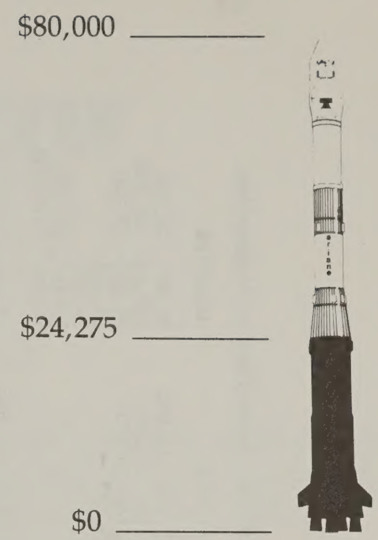
• USKA (a Switzerland-based Amateur Radio organization) which is AMSAT-NA Life Member Society Number 001 has donated $578.87!

• Herbert Merrill, W5GN, donated $1,000. Thank you, Herbert!

• Clyde Charles, WB2TUA, AMSAT-NA Life Member 283, renewed his Life Membership! Sending monthly donations of $50 each, his total contribution amounted to $600. Thank you, Clyde!

• Another loyal and dedicated AMSAT-NA donated $500, however, he requested that his name, callsign, and membership number not be published. A warm, sincere, heartfelt thank you goes to him, anyway!

• The following members donated at least $200: Larry Koziel, H. Jackson, Medical Amateur Radio Council, Arthur Seltzer, David Stockwell, and West Alliis Radio Amateur Club.



• The following members donated at least $100: Gar Anderson, Howard Anderson, Hugh Archer, H. L. Beard, Jon Bloom, Thomas Bolbot, Bill Brown, Anthony Buscaglia, Gilbert Carman, Kenneth Chaffee, Arthur Copeland, Donald Dorson, Wray Dudley, Clay Fisher, Gardner Grout II, Alvin Groff, Enrique Guzman, Elvin Kappler, T. H. Laundry, William Levy, S. B. Davis (Liqui-Box), John Mathias, Robert Neff, Gordon Norris, Robert Payton, Jerry Pixton, Paul Rinaldo, Fred Rollyson, Jack Ross, Rob Roy, Leslie Schneider, W. O'Leary, Paul Sergi, Alice Virginia Shaver, James Shepherd, A. Y. Sprague, Robert Whitehurst, Dana Whitlow, and Thomas Wulling.

AMSAT-NA wishes to express its sincere appreciation to all these members for their loyal and dedicated support, especially during these technically and financially demanding times surrounding the first multi-OSCAR launch!

If we missed your name, please pardon the omission. Just let us know and we'll add it to the next listing of contributors.

Index of Advertisers

AMSAT Orbital Elements from WØRPK

October 15, 1989

Satellite:	AO-10	UO-11	FO-12	AO-13
Catalog number:	14129	14781	16909	19216
Epoch time (89):	269.12984686	273.65105348	273.55938665	272.92824560
Element set:	429	519	172	48
Inclination:	25.9441	97.9913	50.0160	57.1290
RA of node:	242.4999	329.3524	334.4196	188.7304
Eccentricity:	0.6042614	0.0013542	0.0010963	0.6803694
Arg of perigee:	79.3413	352.2728	251.1639	212.3266
Mean anomaly:	339.6974	7.8169	108.8005	77.0853
Mean motion:	2.05878875	14.64057576	12.44401014	2.09705344
Decay rate:	7.6e-07	1.763e-05	-2.5e-07	2.27e-06
Epoch rev:	4729	29797	14252	993

Satellite:	RS-10/11	MIR	SALYUT-7	AJISAI
Catalog number:	18129	16609	13138	16908
Epoch time (89):	277.93244114	278.00169506	277.96627592	258.72253736
Element set:	897	102	795	151
Inclination:	82.9282	51.6200	51.6064	50.0124
RA of node:	157.1078	172.4388	138.2212	19.7646
Eccentricity:	0.0013061	0.0013413	0.0001709	0.0011632
Arg of perigee:	105.0669	121.4571	139.9849	216.4597
Mean anomaly:	255.1938	238.7673	220.1159	143.5447
Mean motion:	13.72010040	15.61869180	15.46009994	12.44380104
Decay rate:	2.00e-06	4.9823e-04	4.0245e-04	-4.5e-07
Epoch rev:	11444	20829	42515	14068

Satellite:	MET-2/16	MET-2/17	MET-2/18	MET-3/2
Catalog number:	18312	18820	19851	19336
Epoch time (89):	278.05081258	278.12017860	277.95307926	277.90611193
Element set:	321	158	78	274
Inclination:	82.5594	82.5468	82.5155	82.5360
RA of node:	132.5090	193.1877	71.7975	98.0455
Eccentricity:	0.0011105	0.0016611	0.0015332	0.0015848
Arg of perigee:	248.7413	326.4926	5.4807	228.4108
Mean anomaly:	111.2553	33.5194	354.6518	131.5650
Mean motion:	13.83526027	13.84210241	13.83844137	13.16863370
Decay rate:	2.19e-06	2.25e-06	1.17e-06	3.91e-06
Epoch rev:	10770	8489	3026	5735

Satellite:	NOAA-9	NOAA-10	NOAA-11
Catalog number:	15427	16969	19531
Epoch time (89):	271.29967929	273.40469874	273.35648977
Element set:	432	285	139
Inclination:	99.1534	98.6327	98.9468
RA of node:	260.3223	301.8706	216.9189
Eccentricity:	0.0015946	0.0013044	0.0011269
Arg of perigee:	27.2759	309.2359	299.9511
Mean anomaly:	332.9247	50.7660	60.0540
Mean motion:	14.12181151	14.23191238	14.11168444
Decay rate:	5.89e-06	6.02e-06	2.69e-06
Epoch rev:	24700	15890	5230

Active OSCAR Satellite Transponder/Beacon Frequencies

Satellite	Mode	Uplink	Downlink
RS-10	A	145.860-145.900	29.360- 29.400
	T	21.160-21.200	145.860-145.900
	K	21.160-21.200	29.360- 29.400
	ROBOT	145.820	29.403
	ROBOT	21.120	29.403
	BEACONS		29.357, 29.403, 145.857, 145.903
RS-11	A	145.910-145.950	29.410- 29.450
	T	21.210-21.250	145.910-145.950
	K	21.210-21.250	29.410- 29.450
	ROBOT	145.830	29.453
	ROBOT	21.130	29.453
	BEACONS		29.407, 29.453 145.907, 145.953
AMSAT-OSCAR 10	B	435.050-435.155	145.955-145.850
	BEACON		145.810
UOSAT-OSCAR 9	BEACON		145.825 FM
UOSAT-OSCAR 11	BEACON		145.826 FM
FUJI-OSCAR 12	JA	145.900-146.000	435.900-435.800
	BEACON		435.797
	JD	145.850	435.910
		145.870	435.910
		145.890	435.910
		145.910	435.910
AMSAT-OSCAR 13	B	435.420-435.570	145.975-145.825
	BEACON		145.812
	L	1269.620-1269.330	435.715-436.005
	J	144.425-144.475	435.990-435.940
	RUDAK	1269.710	435.677
	S	435.601-435.637	2400.711-2400.747
	BEACON		2400.650

All communications within the transponders conform to the Satellite User's Bandplan first proposed by Pat Gowen G3IOR and Joe Kasser G3ZCZ in the September 1979 (Volume IX Number 3) issue of the AMSAT Newsletter. CW is to be found in the low frequency (third) part of the downlink passband, SSB in the high frequency (third) side, and mixed mode QSOs take place in the middle (third) of the passband.

NOTE: All frequencies in MHz.

KENWOOD

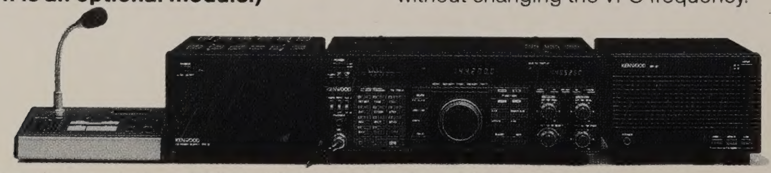
...pacesetter in Amateur Radio

All-mode tri-bander!

TS-790A

Satellite Transceiver

The new Kenwood TS-790A VHF/UHF all-mode tri-band transceiver is designed for the VHF/UHF and satellite "power user." The new TS-790A is an all-mode 144/450/1200 MHz transceiver with many special enhancements such as automatic uplink/downlink tracking. Other features include dual receive, automatic mode selection, automatic repeater offset selection for FM repeater use, VFO or quick step channel tuning, direct keyboard frequency entry, 59 memory channels (10 channels for separate receive and transmit frequency storage), multiple scanning and multiple scan stop modes. The Automatic Lock Tuning (ALT) on 1200 MHz eliminates frequency drift. Power output is 45 watts on 144 MHz, 40 watts on 450 MHz, and 10 watts on 1200 MHz. (The 1200 MHz section is an optional module.)



Complete service manuals are available for all Kenwood transceivers and most accessories. Specifications, features, and prices are subject to change without notice or obligation.

- **High stability VFO.** The dual digital VFOs feature rock-stable TCXO (temperature compensated crystal oscillator) circuitry, with frequency stability of ±3 ppm.
- **Operates on 13.8 VDC.** Perfect for mountain-top DXpeditions!
- **The mode switches confirm USB, LSB, CW, or FM selection with Morse Code.**
- **Dual Watch allows reception of two bands at the same time.**
- **Automatic mode and automatic repeater offset selection.**
- **Direct keyboard frequency entry.**
- **59 multi-function memory channels.** Store frequency, mode, tone information, offset, and quick step function. Ten memory channels for "odd split."
- **CTCSS encoder built-in.** Optional TSU-5 enables sub-tone decode.
- **Memory scroll function.** This feature allows you to check memory contents without changing the VFO frequency.
- **Multiple scanning functions.** Memory channel lock-out is also provided.
- **ALT—Automatic Lock Tuning—on 1200 MHz eliminates drift!**
- **500 Hz CW filter built-in.**
- **Packet radio connector.**
- **Interference reduction controls:** 10 dB RF attenuator on 2m, noise blanker, IF shift, selectable AGC, all mode squelch.
- **Other useful controls:** RF power output control, speech processor, dual muting, frequency lock switch, RIT.
- **Voice synthesizer option.**
- **Computer control option.**

Optional Accessories:
• **PS-31** Power supply • **SP-31** External speaker • **UT-10** 1200 MHz module • **VS-2** Voice synthesizer unit • **TSU-5** Programmable CTCSS decoder • **IF-232C** Computer interface • **MC-60A/MC-80/MC-85** Desk mics • **HS-5/HS-6** Headphones • **MC-43S** Hand mic • **PG-2S** Extra DC cable

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